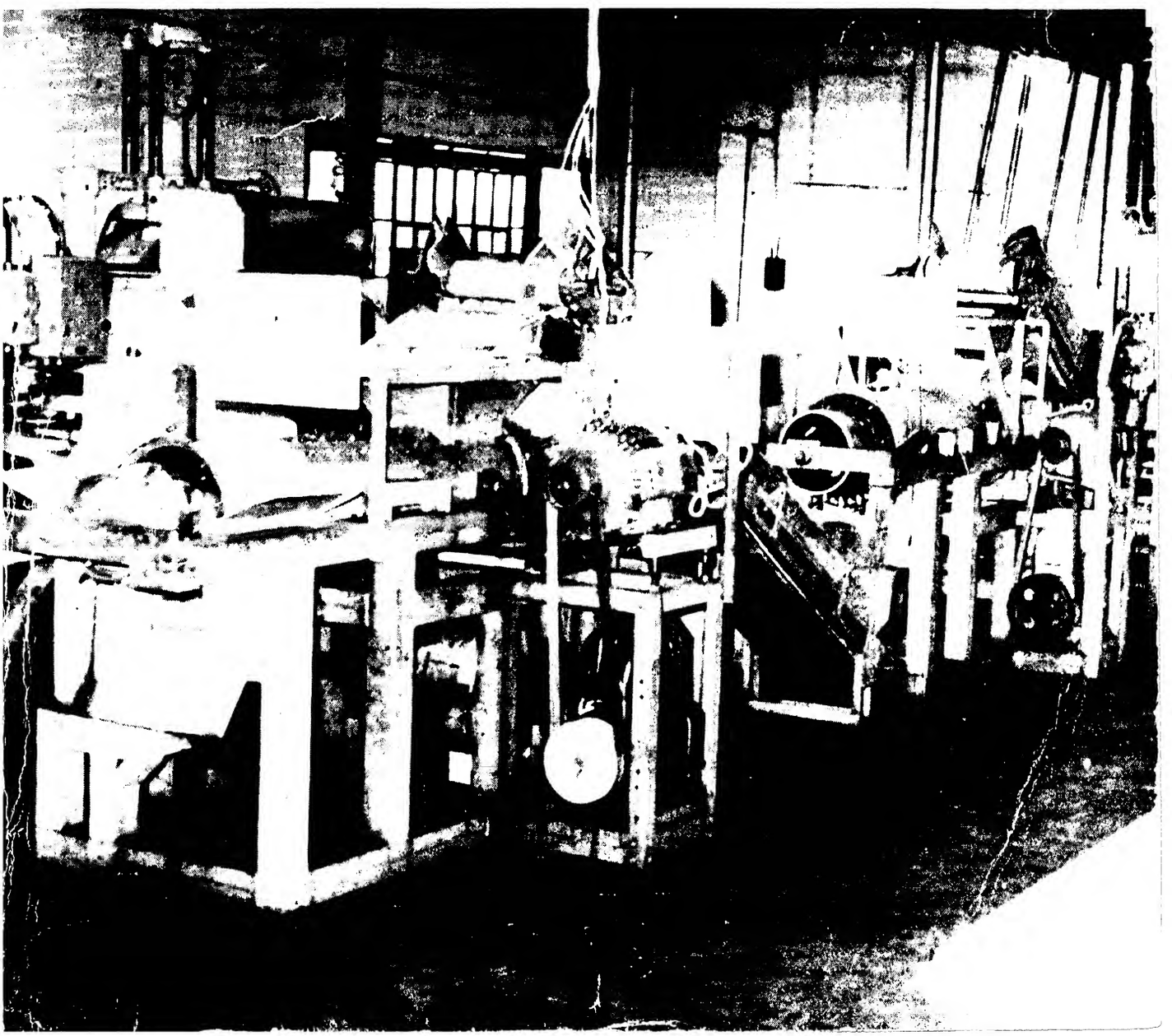
ANNUAL SCIENTIFIC REPORT 1976-77

TEA RESEARCH ASSOCIATION, CALCUTTA



Our Cover

Continuous Tea Roller

TEA RESEARCH ASSOCIATION

Annual Scientific Report

The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April 1976 to 31st March, 1977. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T.R.A., Calcutta.

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Director's Report

(1st April 1976 to 31st March, 1977)

ORGANISATION

On the 31st March 1977, the Senior Staff consisted of :

Directorate :

Director
N. K. Jain, M.Sc. Ag. (B.H.U.), Ph.D. (Illinois)

Adviser
D. N. Barua, B.Sc. (Cal.), Ph.D. (Cantab).

Administration :

Administrative Officer
K. R. Gopalan

Asst. Administrative Officer
B. S. Kotoky, B.A., LL.B.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal.), A.C.A.

Asst. Accounts Officer
P. K. Lala

Maintenance :

Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :

Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publication :

Librarian and Asst. Publication and Information Officer
J. N. Sharma, M.A. (Gau.)

Soils & Meteorology :

Tocklai :

Soil Scientist
S. K. Dey, B.Sc. (Cal.), Assoc. I.A.R.I.

Asst. Soil Scientist
N. G. Bhattacharjee, B.Sc. (Cal.)

West Bengal :

Asst. Soil Scientist
A. K. Sengupta, B. Sc. (Hons) (Cal.)

Botany :

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D. (Gau.)

Asst. Plant Physiologists
B. N. Gogoi, B.Sc. (Gau.)
L. Manivel, M.Sc. Ag. (Madras), Ph.D. (California)

Agriculture :

Agronomist
F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I)

Second Agronomist (Weed Control)
V. S. Rao, M.Sc. Ag. (Osmania), Ph.D. (Cornell)

Estate Manager
A. K. Sahney, B.A. (Delhi)

Entomology :

Entomologist
B. Banerjee, M.Sc. (Cal.), M.S. (South Illinois), Ph.D. (London), F.A.Z., F.R.E.S.(London)

Asst. Entomologist
N. S. Sengupta, B.Sc. Ag. (Dac.)

Mycology :

Mycologist
G. Satyanarayana, B.Sc. (Hons.) (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.

Biochemistry :

Asst. Biochemist
M. R. Ullah, M.Sc., Ph.D. (Gau.)

Tea Tasting :

Tocklai :

Second Tea Taster
A. K. Das, B.A. (Gau.)

West Bengal:

Tea Taster
R. P. Basu

Engineering Research & Development :

Research Engineer
T. C. Baruah, B.Sc. (Hons.) (Gau.), B.Sc. Mech. Eng. (B.H.U.) M. Sc. Mech. Eng. (Manchester)

Statistics :

Statistician
A. K. Biswas, M.Sc. (Gau.)

Agricultural Economics :

Agricultural Economist
R. C. Awasthi, M.Com., LL.B., Ph.D. (Agra)

Advisory :

Senior Advisory Officer
P. C. Sharma, M.Sc. (B.H.U.), Ph.D. (London), F.L.S.

Advisory Officer
T. K. Ghosh, B. Sc. (Patna), Assoc. I.A.R.I., Ph.D. (Cornell)

Upper Assam :
Advisory Officer
J. Chakravartee, M.Sc. Ag. (Gau.)

Lower Assam :
Advisory Officer
B. Borthakur, M.Sc. Ag. (Gau.)

Asst. Advisory Officer
S. C. Dey

North Bank :
Advisory Officer
S. Basu, B.Sc. Ag. (Hons) (Delhi), Assoc. I.A.R.I.

Asst. Advisory Officer
M. Farook, B.Sc. Ag. (T.N.A.U.)

Cachar :
Advisory Officer
S. K. Sarkar, B.Sc. (Cal.), B.Sc. Ag. (B.H.U.)

West Bengal :
Advisory Officer
H. Mitra, B.Sc. (Cal.)

Dooars & Terai :
Advisory Officers
B. C. Barbora, M.Sc. Ag. (I.A.R.I.)
B. C. Phukan, B.Sc. Ag. (Gau.), A.I.F.C.

Darjeeling :
Advisory Officer
R. Padmanaban, B.Sc. Ag. (Madras)

SENIOR STAFF MATTERS

Appointment

Mr. Ashok Sahney was appointed on 23rd June 1976 as Estate Manager for both Borbhetta and Tocklai Divisions.

Transfer

Mr. B. C. Phukan, 2nd Agronomist, Borbhetta, was transferred to Advisory Department as Advisory Officer designate for Dooars on 6th July 1976 and he is stationed at New Chumta Tea Estate, Dooars.

Retirement

Mr. P. K. Lala, Asst. Accounts Officer retired from Association's service on 31st March 1977.

TRAINEES

Two officials from Mauritius, Mr. Y. K. Dwarka and Mr. Ramduth Boodhram, attended four months' training in tea culture from mid September '76 to mid January '77.

Two Vegetative Propagation Courses were conducted and Eight trainees each attended these courses.

One Junior Scientific Assistant under R & D Scheme and another from a T.R.A. member garden, attended short courses of training.

LECTURE COURSES

The following lecture courses were held during the year :

Field Management courses

1st Course from 11th October to 13th October, 1976.
2nd Course from 18th October to 20th October, 1976.

Surveying and Drainage course for Planters

1st Course from 27th December to 31st December, 1976.
2nd Course from 3rd January to 7th January, 1977.
3rd Course from 17th January to 21st January, 1977.

VISITS

The Director proceeds abroad from 22nd August '76 to 23rd November '76, attended C.S.I.R. Governing Body meeting at Delhi from 21st December '76 to 10th January '77. He also visited Calcutta & Lucknow to attend C.D.R.I. meeting from 12th December '76 to 15th December '76, Madras to attend the Governing Body meeting of C.D.R.I. from 25th January '77 to 1st February '77, Calcutta to attend the meeting of Indian Ply-Wood Association from 18th February '77 to 20th February '77, Calcutta to attend Agro-Economic Sub-Committee meeting from 27th February '77 to 1st March '77, Delhi to attend a meeting of C.S.I.R. and discussion with Commerce Ministry from 9th March '77 to 13th March '77, Calcutta from 20th March '77 to 24th March '77.

Dr. F. Rahman attended Agricultural Sub-Committee meeting and A.G.M. of T.R.A. at Calcutta and F.A.I./F.A.O. Seminar in New Delhi.

Dr. V. S. Rao attended Weed Science Conference/Workshop organised by the Indian Society of Weed Science at Hyderabad.

Dr. R. C. Awasthi, Agricultural Economist visited in March & April, 1977 Punjab Agricultural University, Ludhiana for two months training programme in the Department of Economics & Sociology.

Mr. N. S. Venkatakrishnan, Cost Adviser and Mr. S. K. Chakravorty, Senior Scientific Assistant attended the Annual Cost Conference organised by I.C.W.A. at Bombay.

Dr. P. C. Sharma attended a meeting of the Indian Standards Institution, Delhi, in August, 1976 & National Seminar on Tea in New Delhi in November, 1976.

Mr. S. K. Dey visited New Delhi to attend C.S.I.R. meeting on U.N.D.P. Project on 28th June, 1976 and he attended F.A.I. meeting at New Delhi on 8th December, 1976. Again he visited C.S.I.R. New Delhi on 28th December, 1976.

Dr. H. P. Bezbaruah visited National Botanical Garden, Lucknow.

Dr. L. Manivel visited Jute & Agricultural Research Institute, Calcutta.

VISITORS

The following distinguished persons visited Tocklai during the year under review :

Mr. M. S. Kothari, Chief Consultant, Punjab Sector 17, Chandigarh.

Mr. S. K. Mazumdar, Regional Manager, State Bank of India, Shillong.

Messers S. L. Kapur and S. Gundiah of National Chemical Laboratory, Poona-8.

Mr. B. Rajubettan, Chairman, Coonoor Tea Trade Association, Coonoor.

Mr. E. N. Gopichandran, Vice Chairman, Cochin Tea Trade Association, Cochin.

Mr. A. F. Ephraim of Tata-Finlay, Bangalore.

Mr. P. L. Perumal, President, Neelamalai Plantations' Workers Union, Coonoor, Nilgiris.

Mr. M. Lamond, L.S.C., London.

Mr. G. I. D'Souza, Director of Research Coffee Board, Balehonnur.

Mr. I. Pengen Ao, Director of Agriculture, Nagaland.

Mr. M. Shariff, Liaison Officer, Coffee Board, Bangalore-1.

Mr. I. B. Patnaik, Deputy Defence Minister, Government of India.

Brig. C. Vankanga, 41 Sub-Area, C/o 99 A.P.O.

Dr. S. K. Ghosh, Project Co-ordinator, F.C.I., Durgapur-12.

Dr. R. N. Mathur, P-22 Princep St., Calcutta-13.

Mr. F. H. Stroud, Chuapara Tea Estate, Dooars.

Mr. R. Lall, Andrew Yule & Co., Calcutta.

Messers S. P. Popli and V. C. Vora of C.D.R. Institute, Lucknow.

Mr. F. M. Bhatti, Cynamid India Ltd., Bombay.

Mr. A. Bhowmik, Cynamid India Ltd., Calcutta.

Major General M. S. Dhillon, HQ, Eastern Command.

Mr. P. Charles, Camellia Exports.

Mr. S. Y. Padmanabhan, Director, C.R.R. Institute, Cuttack.

Mr. Joseph Thomas, Biology Division, BARC, Bombay.

Mr. Kreshnaduth Mussai, Factory Manager, Tea Investment, Curepaipe, Mauritius.

Mr. M. A. Rabie of Tea Board, Calcutta.

Mr. Y. Hara, Mitsui Norin Co. Ltd., Fujieda, Japan.

Mr. A. Shibuya, Mitsui Norin Co. Ltd., Fujieda, Japan.

Mr. D. E. Neale, Visiting Agent, Malayalam Plantations Ltd., Cochin-3, Kerala.

Mr. D. J. Moffatt, F.A.O., Rome.

Margaret Fulton, Doonan, 7 Simsons Street, Balmain N.S.W. Australia.

Marie McDonald Howes, Writer Home Economist/ Cookery Writer, 1 Rawhit Street, Roseville, N.S.W. 2069, Australia.

Mr. Gurbakhshsingh Sibia, Irrigation & Power Minister, Punjab.

Mr. S. K. Mukherjee, Calcutta University, 35 Ballygunge Circular Road, Calcutta-19.

Mrs. Vidya Stokes, M.L.A., 'Premal', P.O. Thancdhar, H.P.

Mr. Amrit Singh Rathore, A.S.R. Farms, P.O. Pujashi, Simla.

Mr. Ram Rakha Mal, M.L.A.,V. & P.O. Nangran, H.P.

Mr. Thakur Sen Negi, M.L.A., H.P.

Mr. Sita Ram Sharma, M.L.A., H.P.

Mr. Dharam Singh, M.L.A., H.P.

Mr. Bhikham Ram, M.L.A., H.P.

Mr. Siri Ram, Chamber M.L.A., H.P.

Dr. Chabah Kulu, M.L.A., H.P.

Md. Umaruddin, Minister, Agriculture & Irrigation, Assam.

Dr. L. S. Negi, Vice Chancellor, Assam Agricultural University, Jorhat-13.

Mr. J. N. Sharma, Additional Deputy Commissioner, Sibsagar District, Jorhat.

Mr. A. K. Singh, Deohall Tea Estate, P.O. Hoogrijan, Assam.

Mr. P. A. Clayton, Borsapori Tea Estate, Assam.

Mr. D. K. Goswami, Gobindapore Tea Estate, Titabar, Assam.

Mr. R. C. Chib, Indian Institute of Management, Ahmedabad.

Mr. T. R. Govindachari, C.L.R.I., Madras-20.

Mr. G. S. Sidhu, R.R.L., Hyderabad-9.

Mr. W. S. Titus, Hindustan Titus, New Delhi-1.

Mrs. P. P. Trivedi, Commissioner Plains, Gauhati.

Mr. B. P. Pal, P-11, Hauz Khas Enclave, New Delhi-16.

Mr. D. K. Gangopadhya, Deputy Commissioner, Sibsagar, Assam.

Mr. Pradip Mehra, Asst. Commissioner, Jorhat, Assam.

Mr. Rakesh Mehta, Asst. Commissioner, Nowgong, Assam.

Zafar M. Iqbal, Associate Professor, University of Illinois of Medical Centre, Chicago, U.S.A.

Mr. Nirmal J. Singh, Ambassador, Ministry of External Affairs, New Delhi.

Major Gen. V. K. Kaul, National Defence College.

Group Capt. S. K. C. Gupta, National Defence College.

Capt. (I.N.) J. N. Sahul, National Defence College.

Capt. (I.N.) D. M. Gadihoki, National Defence College.

Brig. W. H. J. Withak, British Army, National Defence College.

Brig. G. A. Rassas, National Defence College.

Major Gen. M. C. Gupta, National Defence College.

Air Cdre. M. L. Sethi, National Defence College.

Lt. Col. S. P. R. Nair, National Defence College.

Major Gen. F. A. Ameen, Iraqi Army.

Col. Wali Mohammed, Afghanistan Army.

Advisory

General

Mr. S. Basu took over as Advisory Officer, North Bank and Mr. H. Mitra, in turn, was transferred to the West Bengal Advisory Branch in July.

Mr. B. C. Phukan, Second Agronomist, joined the Advisory Department in December and was posted as Advisory Officer, Terai & Western Dooars in West Bengal.

There has been considerable number of resignations from the cadre of Field-cum-Junior Scientific Assistants both in West Bengal and North Bank and efforts have been made to fill up the vacancies.

The Upper Assam Advisory Branch, was started last year in a rented house in Tingri Circle and arrangements are being made to acquire suitable land for establishment of a full fledged branch. It has also been decided in principle to open Advisory Branches in Tripura and Himachal Pradesh next year.

Visits

Compared to previous year the membership during the current year increased in all areas except North Bank. During 1972-73 total membership stood at 535 covering 73% of the total production in North-East India in 1971 while in 1976-77 the figures went upto 697 and over 82% of the total North-East Indian production during 1975.

Table 1.1 *Details of Advisory Visits paid in the Member Estates during 1975-76 & 1976-77.*

District	No. of visit paid		No. of Member Estates visited during		Total number of Member Estates during	
	1975-76	1976-77	1975-76	1976-77	1975-76	1976-77
South Bank	418	479	295	297	303	312
North Bank	271	223	94	87	100	94
Cachar (including Tripura,	106	154	56	71	64	73
Dooars	316	299	93	106	103	119
Terai	42	69	22	25	23	33
Darjeeling (including Sikkim)	125	112	59	62	59	66
TOTAL	1280	1316	619	648	652	697

There was an increase in the total number of advisory visits to member estates in South Bank. The Advisory Officer, Cachar was over burdened with a large number of visits he had to pay because of the demand even from Tripura Estates. Similar was the picture for Terai in West Bengal.

Crop & Weather

In Upper Assam rainfall during the period March-September was comparatively higher than the previous year. October was variable while the cold weather rainfall was again sufficient except in Naharkatia sub-area where it was rather low during November. Some report of hail storm during the early part was also received from Naharkatia sub-area. Upper Assam estates, except Doom Dooma Circle, registered a marginal decrease in total production.

The distribution of rainfall and the weather condition in the remaining part of the South Bank was comparatively satisfactory except parts of Nowgong and the estates in general closed with a reasonable increased yield.

The weather and crop position in the North Bank was similar to that of South Bank except parts of Upper Assam.

The estates of Cachar took a good start with early and well distributed rain. Some estates in Happy Valley, North Cachar and Hailakandi were affected by hail. Unfortunately, the continuous and heavy spell of rain followed the good early season and the consequent distrous flood in the district during June/July caused widespread damage. Inspite of all these mid season adverse climatic conditions, the district on the whole ended with higher production.

It is interesting to note that inspite of late spring drought the estates of Nagrakata and Chalsa sub-areas did not show any sign of reduction in crop compared to other sub-areas after the droughty spell was over. The periods from July-September and autumn were favourable for crop production. November rain in the Dooars helped unpruned tea. In general, the year was favourable for most estates who made some extra crop.

Wheather in Darjeeling was comparatively favourable and inspite of mild to moderate hail storm in Sonada, Tingling and Teestavalley sub-areas, the total harvest of Darjeeling was higher than during the previous year.

Land Planning and Drainage

We have succeeded in convincing the planters to adopt contour draining but master row planting has not yet been accepted in general. A point that emerged from the various discussions is that if proper land planning is

followed and contour drains are provided, planting across the general slope would ultimately be more or less in straight lines in areas with gentle and uniform slope and if this system is followed it will be nearer to the objective. However, a regular follow up of this idea as well as practical demonstrations have to be arranged to drive this point home.

It has been felt that there is a large scope for improving the drainage system by realigning the drains in existing tea areas but much remains to be achieved yet. In some areas undersized culverts on the railway tracks and the National High way with the bed of the culvert often at a higher level than the general ground level continued to pose problem for easy flow of excess water in many estates. Silted river beds further aggravated the problem by causing back pressure through the main outlets when the rivers remained in spate. A concerted effort should be made by TRA and Industry to appraise the Government to correct the existing drainage situation by providing new culverts of adequate size on the high ways and other roads and by deepening and widening them wherever possible.

TEA HUSBANDRY

Pruning Cycle

As in last year, the tendency for crop oriented pruning cycle continued in all areas with slight modification depending on weather, labour availability and suitability of the sections. It was generally observed that the new wood at the pruning level became considerably thick in long pruning cycles and use of slashing knives caused splitting of wood which is very detrimental. Use of smaller pruning knives can avoid such damage. At the same time, emphasis was given to the need of leaving comparatively longer wood following an extended pruning cycle. In North Bank, a number of estates kept the bushes unpruned where irrigation was assured.

In Darjeeling, conventional five-year cycle like LP-UP-LS-DS-UP in the mid and higher elevations continued to be followed while a shorter cycle was followed in lower elevation and on Assam hybrid teas.

A point of interest was that in the Dooars late pruning even after middle of January was followed by some estates with the idea of harvesting more back-end crop. This may, however, result in some loss of early crop.

Rejuvenation

In successfully rejuvenated plots where infills have been established, it was observed that the yield in the third year after rejuvenation exceeded the average yield before rejuvenation. Some cases of failure have also been reported which were mainly due to wrong selection of sections in respect of vacancies, age, kind of tea, drainage, substandard infills and their proper care etc.

Rejuvenation pruning as a treatment mainly against *Aglaospora* and for rehabilitation was done on large scale in Darjeeling and the Tea Board incentive induced many estates to introduce this method of improving old teas.

Plucking

Black plucking was tried by some estates and the experiment indicated that it is good only for vigorous teas and where the shoot growth was faster. Under most other conditions, this system of plucking was not found suitable. As a result most of the estates did not adopt this system of plucking and continued to follow standard method of plucking except a few of the South Bank estates.

In the North Bank, black plucking did not increase the crop. This could be attributed to the fact that the plucking was so hard that in some cases even the janams were erroneously removed resulting in practically no rise of the plucking table. This was undesirable.

In Cachar estates black plucking did not prove beneficial.

Bushes in the Dooars and Terai which were plucked hard suffered most from the late spring drought.

Darjeeling's main problem has been to improve the efficiency of plucking. The size of the shoots, pruning cycle, slope, height of the bushes, plucker's efficiency and shortage of pluckers had a combined effect on the yield of Darjeeling tea. To obviate some of these difficulties, various combinations of pruning treatments and their timing were tried. As in other areas, the chronic problem of inadequacy of labour during the peak season, particularly for the unpruned teas, still remained a problem there in Darjeeling.

Young Tea

In most areas a population of 16,000 to 20,000 plants per ha has become more common than in the past. Some companies in Upper Assam accepted pegging as the method of bringing up young tea while others continued to follow normal decentering and frame formation prune. On the contrary, pegging of young tea has not yet been fully familiarised in the other parts of South Bank although odd estates are giving the method a fair trial. Those estates where the method of pegging has not yet gained popularity, the main reason appeared to be the initial high expenditure and requirement of intensive supervision with proper follow up which could not be made available to those areas.

North Bank estates have also been trying "tram line" pegging in a limited way. It appears that the success of this system of bringing up young tea is closely associated with a very high yield during the first 2-3 years to cover up the expenditure involved.

While pegged bushes had the advantages of very little recentering at the time of frame forming prune, in some cases, pegged branches seemed to be suceptible to sunscorch damage when they were exposed to sudden

insolation. In such cases, protective measures like covering the exposed frame with pruning litters could be considered.

In the Dooars & Terai, however, pegging was practised only in a limited way. Normal method of centering, recentering with the frame forming prune has rather been followed.

Darjeeling estates seemed to have shown some keenness to uprooting and replanting and also to extension. Infilling in the rejuvenation plots has already taken a start with the incentive of the Tea Board Subsidy Scheme.

In general more attention was paid to young tea areas all over and the standard of management improved considerably. Young tea received the priority for mulching in all areas and at the same time attention was paid to keep them weed free as much as was possible. In this regard some estates came up with chemical weed control programme in young tea in a big way.

Planting

Extension planting, wherever land was available, continued to receive top priority inspite of constant advice on the need of uprooting and replanting.

Most of the estates have already planted up the suitable areas and many of them went ahead with comparatively marginal and sub-marginal land with the hope that advanced technology on soil and bush management would be able to deal with the problems associated with such areas.

Block infilling of old tea was favoured more than individual infilling as block infilling seemed to require comparatively less attention which the estates could afford to offer at present. However, there were examples of estates particularly, in Goalpara sub-area where significant increase in crop from infilled sections was claimed. TV9 and TV18 remained more popular for infilling and lately TV19 is also being tried. In most cases, planting pits did not appear to meet the standards laid down by Tocklai.

PROPAGATION

(a) **Clonal Selection**

Substantial increase in the number of enthusiastic estates for clonal selection kept both the Advisory as well as the Plant Breeding teams on their heels. It is hopped that more and more estates would join the scheme and in near future a handful of good clones would be available to the industry.

(b) **Vegetative Propagation**

Increasing number of estates were inducted to adopt north light overhead shade nursery and the overall performance of this type of nurseries, was highly satisfactory. However, cases have been reported where faulty watering, late transplanting into the sleeves etc led to poor success but these are being solved gradually to the advantage of the estates.

Wherever TV18 is available, it has been replacing TV9. Teen Ali 17/1/54 is also becoming more popular in some of the droughty areas. Estates have also taken interest in propagation the newly released Tocklai clones like TV19, TV20, TV21, TV22 & TV23. In odd cases where poor growth of cuttings was associated with sub-acidity, aluminium sulphate appeared to have helped the growth of the cuttings.

Vegetative propagation work has not gained momentum in most of the Darjeeling estates. This resulted in shortfall of available plant material for replanting and extension in the district after the demand for infilling was met.

(c) **Seed**

A number of estates continued to show interest in establishing seed baris of Tocklai biclonal stock 449, 450 & 397. As these seeds are not easily available, many estates are still using stock 203.

Heavy demand for Nanda Devi seed continued to pour in from Darjeeling estates.

FERTILIZER

(a) **Nitrogenous Manures**

The tendency of over-manuring appeared to be declining. Most estates restricted their manuring to the higher limit of 135 kg N/ha. However, there are still exceptions. During the course of visit, it was also observed that some estates continued to apply the highest recommended dose (135 kg N/ha) uniformally over the entire estate irrespective of the yielding capacity of the sections or shade status. Efforts were made to dissuade the managers from this practice.

(b) **Potash Manuring**

Except in West Bengal, potash manuring on the basis of soil analysis continued.

In West Bengal, application of 40 kg K_2O/ha as routine practice once in three years was adopted. There were occasions when it was felt that higher doses upto 100 to 120 kg K_2O ha could benefit the bushes. These rates were accordingly tried and were reported by the management as useful. However, final results of the trials are still awaited for a firm recommendation for West Bengal.

(c) **Foliar Application of Urea & Zinc**

Reports of beneficial effects from foliar application of urea during autumn and cold weather and that of zinc during the early season, particularly in old and replanted teas were received practically from all over the area although the final result of the estates trials is still awaited. Spraying of Magnesium sulphate was also claimed as beneficial for some tea in the Dooars.

(d) **Spraying of Micronutrients**

Many estates have started spraying of micronutrient mixture easily available in the market at their own initiative and a few estates have claimed beneficial results. New experiments have already been planned and are being initiated by the department to test the validity of such claims.

(e) **Manuring of Young Tea**

Liberal manuring of young tea continued all over. New experiments have already been designed to find out the optimum requirement in the context of the new method of bringing up young tea.

Weed Control

The problem of weed control in young tea was more acute than in mature tea. The reasons are two fold - firstly, the use of herbicide in young tea areas requires special attention and secondly, the ground coverage is much less compared to mature tea and, therefore, the growth of weed is more profuse. Nevertheless, use of herbicide both in mature and young tea continued to increase.

No suitable herbicide is available to the industry to keep the resistant weeds like *Polygonum chinense*, *Diascoria balbifera*, *Ipomea cymosa*, *Setaria palmifolia* and *Digitaria sanguinalis* under control. Hand removal of the weeds around the collar of young tea and in some cases, in mature tea also was practised. Use of pre-emergent weedicides like Diuron appeared somewhat effective in odd cases.

Mulching

With the growing awareness for mulching young tea as reported earlier, slow decomposing material with the addition of 20 kg N/ha continued to be used. In the Dooars some estates tried to make the best use even of *Mikania* as a mulch. Fresh cuttings of *Mikania* were spread in the interrow space and 2,4-D at 1 in 400 was sprayed immediately although the danger of fresh rooting of cuttings, in case of failure to spray them thoroughly can not be completely ruled out at this stage.

The estates of low and mid elevations in Darjeeling were now more concious and are trying to grow Guatemala for the purpose of mulching. In the higher elevation, efforts were made to grow fodder sugarcane (Co 290, Co 301, NB 19 & 21).

Shade

Planters are aware that a correct stand of shade in tea is necessary. In an attempt to achieve this, thinning out of shade in the heavily shaded areas, reshading where necessary, and/or replacing the old ones gained momentum except in the Dooars.

In the Dooars, shade trees have been deteriorating fast mainly due to ageing and storm injury coupled with pests and diseases. The shade in young tea remained generally poor. Shade tree nurseries in the Dooars was yet to be considerably improved. September planting of shade trees was reported successful in the Dooars.

In Darjeeling, shading of tea in high and mid elevations, and in the northern aspects is not followed. In low elevations, *Sesbania sinerescences* was being introduced as a temporary shade.

PEST & DISEASE

(a) **Pest**

Mites still continued to be problem for many estates of Assam including Cachar. Red spider and scarlet mite were more abundant in the early part of the season and in Upper Assam, these were observed in September as well. Looper caterpillar caused large scale damage in many estates around Tezpur, Orang and Borsola sub-areas during April-July. Bunch Caterpillar also appeared in some estates of Golaghat and Moran sub-areas of the South Bank. The situation with looper became quite serious in some estates of the north as well as the south bank and all the approved insecticides failed to control looper specially when they were full grown. Badly affected sections were treated liberally by increasing the tipping measure and by applying extra manure for better recovery.

Thrips were on the increase. Hard plucking followed by spraying of insecticide improved the situation in most cases. Green fly and flush worm were also observed more in the pruned and deep skiffed areas. Regular spraying against green fly in combination with plucking of the flush worm affected shoots helped to control the situation in many cases.

Caterpillars were mainly confined to shade tree. Regular spraying against these insects both in the nursery and after transplanting in the field for 2-3 years was stressed during advisory visits.

In the Dooars, increased incidence of purple, scarlet and pink mites was observed. As in Assam, thrips and green fly continued to pose threat to the early flush and several rounds of Thiodan had to be repeated. Looper created similar problem in a number of estates in the Eastern Dooars. *Baradesa omissa* a pest of *Derris robusta* was increasing during the last couple of years in Dooars and Terai.

In Darjeeling, green fly, mites and thrips continued to be the major pests. The estates of Darjeeling had not yet taken effective steps to control the green fly and thrips for the fear of loosing the quality and flavour although there is danger of potential loss of crop. Red spider was unusually heavy during October and November and caused defoliation at a later stage. This was particularly true for hybrid and Assam teas. Hairy caterpillar was observed in localised patches in a few low elevation estates.

(b) Diseases

While red rust was not much of a problem in the North Bank, black rot appeared in some heavily shaded sections, particularly in estates where timely spraying was not done. On the contrary, report of red rust and black rot were more common in the other parts of Assam including Cachar. Primary root diseases including charcoal stump rot and black root rot were observed. A couple of cases of red root rot was also reported. While the conventional method of controlling the spread of these diseases by uprooting the affected ones and by digging trenches continued, soil fumigant against these primary root diseases were tried by some estates with promising results. Blister was a cause for concern both in South and North Bank and some estates claimed to have lost some early crop inspite of regular spraying with copper fungicide. This disease was observed more in pruned, deep skiffed and heavy pruned areas.

Black rot and red rust continued as major diseases in the Dooars and Terai, while blister blight was rated first in the order of importance in Darjeeling. Mild incidence of red rust also observed in Darjeeling in some of the mid elevation estates.

Primary root diseases were on the increase in the Dooars and Terai but, no effective control measure was yet taken by the estates. *Aglaospora* continued to pose a problem to many Darjeeling estates. Root spliting disease (*Armillaria mellea*) was found to have done considerable damage to tea in Sikkim while other primary root diseases reported elsewhere were also observed in Darjeeling.

Small reddish brown spots on tender leaves, internodes and even on buds were recently observed and studies were in progress to establish its causes and assess its economic importance in Darjeeling tea. The spots normally appeared after June and its incidence was observed more in high elevation, particularly in unpruned China hybrid.

Advisory Out-Station Plots and Experiments

The plots at the out-stations were maintained for distribution of cutting of Tocklai released clones to the member estates and for conducting some look-see trials.

(a) Release of Tocklai Clones

The details of distribution of cuttings, generative clones and seeds from various out-stations and Tocklai to member estates are given in Table 2.

Table 1.2. *Distribution of cuttings, scions, generative clones and seeds from various Out-Stations and Tocklai*

Out-Stations	VP cuttings	Scions	Generative cuttings	Generative scions	Seeds (in kg)	Plants
South Bank	877,467	4,770	22,165	675	710 (Nandadevi seed from Borbhetta)	—
North Bank	240,600	687	—	—	—	—
Cachar	127,441	20	—	—	—	70
Dooars & Terai	584,906	5,820	17,450	4,545	225 (Nanda Devi)	—
Total	1830,414	11,297	39,615	5,220	935	70

(b) Green Leaf

Green leaf harvested from different out-station plots are stated below :

North Bank : 4,724 kg
Cachar : 5,524 kg
Nagrakata : 29,294 kg

(c) Experiments

The following trials were in progress at Nagrakata Branch plot.

(i) Long term agricultural trials with different clones.
(ii) New long term trial with different clones.
(iii) Nitrogen response to different clones.
(iv) Biclonal stock trial with various Tocklai stocks.

(d) Quality Testing Scheme

Only one clone was offered for testing which was planted out in 1976. Four Kopati clones were also planted out in autumn 1976.

(c) Clonal Proving Station (Darjeeling)

The details of the trials conducted at the clonal proving station, Darjeeling are presented below

Table 1.3. *Details of experiments in Clonal Proving Station, Darjeeling*

Sl. No.	Trial No.	Year of planting	No. of clones tried	Seed jat tried	Certified	Remarks
1.	A	1967	19	—	7 clones	Under trial
2.	C	1969	6	1	Under trial	-do-
3.	D	1970	6	1	-do-	-do-
4.	E	1971	6	—	-do-	-do-
5.	F	1973	8	—	-do-	-do-
6.	G	1974	7	—	-do-	-do-

Three clones from trial 'B' and two from trial 'C' have been certified for Darjeeling.

During the year under report, 1,325 samples were manufactured for evaluation of quality. The follow-

ing clones and jats were planted during 1976 for performance studies.

1. Badamtam 16a/573
2. Badamtam 16c/138
3. Keyhung 1
4. Phoobsering 1315
5. Phoobsering 1348
6. Phoobsering 1404
7. RSY 12/40
8. HV 39
9. Stock 465
10. Nanda Devi Stock 378.

(f) Field Experiments on Tea Estates

During 1976-77, a number of experiments on rejuvenation, infilling, plucking, NPK manuring etc were continued. A complete and detailed list of these experiments, conducted by this department is given in Appendix A.

(g) Area Scientific Committee Meetings/Seminars

The number of meetings held in the various districts is given below :

South Bank East	: 2
South Bank Central	: 3
South Bank West	: 6
North Bank East	: 1
North Bank West	: 1
North Bank E&W joint	: 4
Cachar	: 4
Dooars	: 4
Terai	: 3
Dooars & Terai joint	: 1
Darjeeling	: 2

With the Area Scientific Committee meetings, open sessions were also held for the planters of the area to discuss the local problems and these were well attended. These meetings and open sessions proved to be useful platforms for free exchange of ideas between the planters and the scientists. The details of the Seminars held during 1976–77 are given below :

South Bank East	: One seminar on Engineering & Manufacture.
	One Seminar on Plucking & Manuring.
South Bank Central	: One seminar on Engineering & Manufacture.
South Bank West	: One seminar on weedicide & pesticide.
North Bank East & West	: Two seminars on pruning.
	One seminar on Agriculture and Soil Science.
	One seminar on Plantation at Goalpara.
	One seminar on plant protection.
	One special seminar on "How to improve yields from existing tea".
Cachar	: One seminar on Manufacture.
	One seminar on Improved Agricultural practices towards high productivity in tea.
	One seminar on Drainage.
Dooars	: One seminar on Pruning.
	One seminar on Pest & Disease.
Terai	: One seminar on Engineering & Manufacture.
	One Seminar on Pest & Disease.
	One seminar on Pruning.

(h) Lecture Courses

Two lecture courses on "Field Management", each of three days duration and three lecture courses, each of five days duration, on "Surveying & Drainage" for planters were held during the year. The courses were well attended.

Summary of Results

Summaries of a few interesting experiments conducted by this Department are given below :

(a) **Rejuvenation Experiments**

(i) **Assam, South Bank Experiments (Nos. AS. 128, AS. 130 & AS. 131)**

Three experiments, one each in Tara, Teloijan and Khumtai Tea Estates were laid out during 1974, the results of which are presented in Table 1.4.

Table 1.4. *Yield of made tea in kg/ha for the year 1976*

	Treatments	Experiment Nos. AS 128	AS 130	AS 131
T_1	No rejuvenation (control)	2197	2334	900
T_2	Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	2583	1885	767
T_3	Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge, i.e., if the original spacing was 150 cm × 150 cm make it into 150 cm × 75 cm.	2439	1753	789
T_4	Prune in July/August and infill in the autumn as in T_2	1750	1239	718
T_5	Prune in July/August and infill in the autumn as in T_3.	1586	1311	768
L.S.D. P .05		71	430	NS
C.V.%		1.21	9.09	9.87

In AS. 128, cold weather pruning treatments T_2 and T_3 caused significant increase in crop over July/August pruning (T_4 and T_5) and over control (T_1). In AS. 130 also T_2 and T_3 significantly out-yielded T_4 and T_5, although control continued to produce the highest yield. In both the experiments, interplanting had not yet shown any special advantage. The treatment differences were not significant in the third experiment, AS. 131, mainly because of the failure of the infills to grow satisfactorily due to continuous damage from cattle trespass.

(ii) **Dooars, West Bengal Experiments (Nos. D. 43, D.44, D. 45, D. 46 & D. 47)**

Five experiments, one each in Dalgaon, Matelli, Kilcott, Rydak and Kumlai Tea Estates were laid out during 1972. The results are presented in Table 1.5.

In Experiment Nos. D. 45 & D. 46 rejuvenation during cold weather T_2 & T_3) produced significant increase in yield over July/August pruning (T_4 & T_5). Although the trend was similar in other experiments, the treatment differences were not significant. Except in D.43 & D. 47, the highest crop still continued to be harvested from control plots. It is possible that by next year rejuvenated plots will out yield control plots when the infills come into full bearing.

Table 1.5. *Yield of made tea in kg/ha for the year 1976*

	Treatments	Experiment Nos. D.43	D.44	D.45	D.46	D.47
T_1	No rejuvenation (control)	1085	1498	1759	1725	902
T_2	Cold weather pruned and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	984	1311	1282	1296	1158
T_3	Cold weather prune and-infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original spacing was 150 cm × 150 cm make it into 150 cm × 75cm	1357	1307	1258	1323	1093
T_4	Prune in July/August and infill in the autumn as in T_2	968	1189	1137	1073	850
T_5	Prune in July/August and infill in the autumn as T_3	1154	1338	1189	1282	1033
	LSD (P .05)	NS	NS	91	184	NS
	C.V. %	12.49	5.95	2.56	4.95	10.02

(b) **Infilling Experiments**

(i) **Assam Experiments (Nos. AS. 129, AS. 132, AN. 140 & AN 141)**

Four experiments on infilling were initiated in South & North Bank of Assam during 1974. Although infilling with three plants per vacancy i.e. double the number plus one, using both seed and clonal plants increased the yield by an average of about 3.0% over no infilling, the difference was not significant. The beneficial effect of infilling is likely to show up better when infills come in to full bearing.

(ii) **West Bengal Experiments (Nos. TR.3, TR.4, D. 37, D. 40 & D. 41)**

Five experiments on infilling were laid out in West Bengal during 1969, the results which are presented in Table 1.6.

Inspite of substantial yield increase from infilling, the differences were not statistically significant. The combined analyses of these results is in progress.

(iii) **Darjeeling Experiments (Nos. Dj. 36 & Dj.37)**

The results of Darjeeling experiments also showed that infilling could increase yield to some extent against no infilling although these increases were not significant.

(c) **Foliar application of zinc**

(i) **Assam South Bank Experiments (Nos. AS 109, AS 112, AS 115 and AS 121)**

Four experiments, one each in Panitola, Sepon, Daimukhia and Bokakhat tea estates were conducted in the South Bank. The results are presented in the table 1.7.

Table 1.6. *Yield of made tea in kg/ha for the year* 1976

Treatments	Experiment Nos.					Total of all expts.	Average increase in percent over control
	TR.3	TR.4	D.37	D. 40	D.41		
T_1 — No infilling.	1507	598	1547	2080	1278	7010	-
T_2 — Infilling with seedling at one plant per vacancy	1566	652	1816	2155	1712	7901	12.7
T_3 — Infilling with clone TV9 at one plant per-vacancy.	1478	809	1757	2314	1763	8391	19.7
T_4 — Infilling with seedlings in a hedge i.e. double the number of plants per vacancy plus one	1481	735	1712	2219	1208	7335	4.6
T_5 — Infilling with clone TV9 in a hedge i.e. double the number of plants per vacancy plus one	1787	793	1903	2357	1832	8672	23.7
L. S. D. (P = .05)	NS	NS	NS	NS	NS		
C.V.%	5.35	11.60	8.13	1.64	14.56		

In Experiment No. AS 109, zinc sulphate at the rate of 12.5 kg per hectare increase the yield significantly over control, 25 kg and 50 kg zinc sulphate per hectare while there was no significant difference between 25 and 50 kg applications.

No significant difference in yield due to various rates of zinc sulphate was observed in experiment No. AS 112 but all of them increase the yield significantly over control.

Table 1.7. *Yield of made tea in kg/ha for the year* 1976

Treatments \ Expts. Nos	AS 109	AS 112	AS 115	AS 121
T_1 No zinc	1568	1287	2765	2170
T_2 12.5 kg Zn/ha	1790	1573	3234	2661
T_3 25 kg Zn/ha	1662	1675	2938	2835
T_4 50 kg Zn/ha	1716	1798	2986	2668
L.S.D. (P .05)	64	338	232	150
C.V. %	2.1	11.8	4.3	3.1

Yield of tea increased significantly by the application of 12.5 kg zinc sulphate per hectare compared to no zinc 25 and 50 kg zinc sulphate per hectare in experiment No. AS 115.

In AS 121 however, significant increase in yield was obtained by the application of zinc sulphate at all rates over control and the highest yield obtained from 25 kg zinc sulphate per hectare maintained its significant superiority over the other two rates.

(ii) **North Bank, Assam**

Two experiments were conducted one each in Monabarrie (AN 117) and Tezpur & Gogra (AN 124) in the North Bank. The results are presented in table No. 1.8.

Table 1.8. *Yield of made tea in kg/ha.* 1976

Treatments	Experiment Nos	
	AN 117	AN 124
T_1 – No zinc	2637	2280
T_2 – 12.5 kg Zn/ha	2692	2289
T_3 – 25 kg Zn/ha	2688	2257
T_4 – 50 kg Zn/ha	2902	2274
L.S.D. (P – .05)	148	NS
C.V. %	2.96	4.10

In experiment No. AN 117, zinc sulphate at the rate of 50 kg/ha increased the yield significantly over control, 12.5 and 25 kg zinc sulphate per hectare. No significant difference in yield due to various treatments was observed in experiment No. AS 124.

(iii) **Cachar and Darjeeling**

Two experiments each in Cachar and Darjeeling were continued during 1975/76 where application of zinc sulphate failed to demonstrate positive beneficial effect over control. In Cachar one experiment was affected by flood and the other by waterlogging.

(iv) **Dooars**

Three experiments were conducted, one each in Kartick (D 52), Baradighi (D 53) and Bhogotpore (D 54) Tea Estates. The results of 1976 are presented in table No. 1.9.

Table 1.9. *Yield of made tea in kg/ha,* 1976

Treatments	Experiment Nos.		
	D 52	D53	D 54
T_1 – No zinc	3545	3048	2056
T_2 – 12.5 kg Zn/ha	3921	2717	1972
T_3 – 25 kg Zn/ha	3491	2789	2157
T_4 – 50 kg Zn/ha	3439	2834	1968
L. S. D. (P – .05))	322	NS	NS
C. V.%	4.92	8.2	3.05

In experiment No. D 52 zinc sulphate at the rate of 12.5 kg/ha increased the yield significantly over control, 25 kg and 50 kg zinc sulphate per hectare.

In the other two experiments D 53 and D 54, application of zinc sulphate failed to show positive beneficial effect.

(d) **Urea trial at Duklingia T.E. (No. AS 125)**

One experiment on soil and foliar application of urea was continued in the South Bank from 1973. The results for the year 1976 are presented in Table 1.10

It can be seen that all the nitrogen treatments including soil as well as foliar application of urea significantly out-yielded the control. There was no apparent gain from foliar application of urea over soil application.

(e) **Nitrogen experiment with and without mulch (No. AN 138)**

This experiment was conducted in the North Bank, Assam (Sessa Tea Estate) to study the effects of nitrogen alone and in combination with mulch. In the first year of the experiment during 1976, the tea was light skiffed.

Table 1.10. *Yield of made tea in kg/ha,* 1976

Treatments	Yield
T_1 – Normal ground application 90 kg N/ha	1144
T_2 – Normal ground application 135 kg N/ha	1148
T_3 – Foliar application 90 kg N/ha (every fortnight April-November)	1168
T_4 – 60 kg N soil application + 30 kg N foliar application (from March – May)	1152
T_5 – 60 kg N soil application + 30 kg N foliar application (from June – August)	1150
T_6 – 60 kg N soil application + 30 kg N foliar application (from September – November)	1118
T_7 – 105 kg N soil application + 30 kg N foliar application (as under T_4)	1100
T_8 – 105 kg N soil application + 30 kg N foliar application (as under T_5)	1133
T_9 – 105 kg N soil application + 30 kg N foliar application (as under T_6)	1144
T_{10} – Control (no manure)	870
(P = .05)	58
L.S.D. (P = .01)	78
(P = 3.59)	104
C.V.%	3.59

Although difference in yield was not significant at 5% level mulching at all the nitrogen levels appeared to show some additional gain. Highest yield was obtained when 125 kg N/ha was applied along with mulching.

Table 1.11. *Yield of made tea in kg/ha for the year* 1976

Treatments	Yield
T_1 – 90 kg N/ha without mulching (control)	2984
T_2 – 90 kg N/ha with mulching	3065
T_3 – 100 kg N/ha without mulching	3031
T_4 – 100 kg N/ha with mulching	3131
T_5 – 125 kg N/ha without mulching	2977
T_6 – 125 kg N/ha with mulching	3266
T_7 – 150 kg N/ha without mulching	2986
T_8 – 150 kg N/ha with mulching	3155
L.S.D. (P = .05)	NS
C.V.%	6.82

(f) Plucking experiment at Birpara T.E. (D. 58)

This experiment was initiated in 1974 to compare the yield from T_1 (black plucking) and T_2 (standard plucking) under different types of pruning. In 1976, pruning treatments included M_1 (deep skiff), M_2 (medium skiff), M_3 (unprune) and M_4 (light prune).

Table 1.12. *Yield of made tea in kg/ha for the year* 1976

Treatments	M 1 DS	M2 MS	M 3 UP	M 4 LP	Mean
T_1(Black plucking)	1956	1883	2351	1640	1958
T_2(standard plucking)	2268	1795	2649	1899	2153
Mean	2112	1839	2500	1769	
L.S.D. for main plot treatment Mean		(P = .05)		431	
L.S.D. for sub plot treatment Mean		(P = .05)		116	
C.V.%				9.32	

Analysis of results of 1976 showed that standard plucking, in general yielded more crop than black plucking and this difference was significant. When the two systems of plucking were compared seperately under various types of pruning/skiffing, standard plucking still remained superior to black plucking except when the bushes were medium skiffed. Significantly more crop was produced by unpruned than by deep skiff, medium skiff and light pruned treatments under both the systems of plucking.

(g) Cultivation experiment

One experiment in the South Bank at Deohall tea estate, Hatimara Division (AS 134) was initiated in 1975 to compare the effects of various methods of cultivation and chemical weed control in a heavy soil.

Table 1.13. *Yield of made tea in kg/ha for the year* 1976

Treatments	Yield
T_1 Check (chemical weed control)	1450
T_2 One deep hoe in June	1411
T_3 One deep hoe in December	1422
T_4 One deep hoe in June and one deep hoe in December	1453
T_5 One fork hoe in June	1456
T_6 One fork hoe in December	1522
T_7 One fork hoe in June and one fork hoe in December	1488
T_8 Sickling at intervals throughout the year	1379
L.S.D. (P = .05)	NS
C.V.%	7.24

No significant difference in yield due to treatments was observed in 1976, the first year of experimentation. However, during the first year of imposing the treatments, one fork hoe in December (T_6) appeared to be beneficial in terms of yield followed by the treatment in which an additional fork hoeing was done in June (T_7).

(h) Pruning cycle experiment (Dj. 24)

All the pruning cycles were completed in 1976 and complete analysis of the data is in progress. Treatment yields for the year 1976 only are presented in table 1.14.

Table 1.14. *Yield of made tea in kg/ha* 1976

Treatments	1976
1. LP – Lvs – Ls	1858
2. LP – Lvs – MS	1254
3. LP – Lvs – DS	1328
4. LP – Lvs – LS – Lvs	1654
5. LP – Lvs – MS – Lvs	2086
6. LP – Lvs – DS – Lvs	1825
7. LP – Lvs – LS – Lvs – LS – Lvs	1699
8. LP – Lvs – MS – Lvs – MS – Lvs	1899
9. LP – Lvs – DS – Lvs – DS – Lvs	1957
10. LP – Lvs – Lvs – MS – Lvs – Lvs	2021
11. LP – Lvs – Lvs – DS – Lvs – Lvs	2244
12. LP – LS – LS – DS – LS – LS	2207
L.S.D. (P = .05)	278
C. V.%	14.0

LP=Light prune, DS=Deep skiff, MS = Medium skiff, LS=Light skiff, Lvs=Level ofi skiff.

Comparison amongst the 3, 4 and 6 year cycles shows that the six year cycle treatment T_{11} (LP-Lvs-Lvs-DS-Lvs-Lvs) significantly out yielded all other treatments except T_3 (LP-Lvs-MS-Lvs), T_{10} (LP-Lvs-Lvs-MS-Lvs-Lvs) and T_{12} (LP-LS-LS-DS-LS-LS) in 1976 in Darjeeling.

Amongst the three year cycle treatments, T_1 (LP-Lvs-Ls) produced significantly the highest crop.

Amongst the four year cycle treatments, T_5 (LP-Lvs-MS-Lvs) yielded significantly increase in crop over treatment T_4 (LP-Lvs-Ls-Lvs) but failed to maintain its significant superiority over treatment T_6 (LP-Lvs-DS-Lvs) by a narrow margin inspite of yielding considerably more crop. Out of the various six year cycle treatments T_{11} (LP-Lvs-Lvs-DS-Lvs-Lvs) produced significant gain in yield over T_7 (LP-Lvs-LS-Lvs-LS-Lvs), T_8 (LP-Lvs-MS-Lvs-MS-Lvs) and T_9 (LP-Lvs-DS-Lvs-DS-Lvs).

A clear picture is likely to emerge when the combined analysis of the results of all the years are completed.

Tea responds only upto a certain level of nitrogen beyond which the response is negative. Chemical weed control combines the beneficial effect of cheeling and mulching. April to September is the critical period for weed competition in young tea at Borbhetta. Roundup is the most effective herbicide for thatch and many other problem weeds.

Planting and spacing

One factorial experiment (B. 8/1) was initiated in 1966, with four plant-to-plant spacings (at a constant row spacing of 120 cm), three nitrogen levels (100, 200, and 300 kg/ha) and two clones (TV 1 and TV 9).

The three-year (1974-76) data indicated that the closest spacing of 120 cm ×22.5 cm gave significantly higher yield than all other spacings (Table 3.1). There was no difference between 120 cm × 30 cm and 120 cm × 45 cm spacings. These two spacings were significantly

Table 3.1. *Effect of different spacings on yield of clonal tea (made tea kg/ha)*

Spacing (cm)	Plant population/ha	1974 D.S.	1975 M.S.	1976 L.P.
120 × 90.0	9,260	1639	1552	1333
120 × 45.0	18,520	1875	1809	1524
120 × 30.0	27,780	1882	1850	1562
120 × 22.5	37,040	2215	2108	1875
L.S.D. (at 5% level)	---	261	231	212
C. V. (%)	---	16.1	14.8	16.0

superior to the widest spacing (120 cm × 90 cm) in 1975. In 1976 only the 120 × 30 cm spacing was significantly superior to the widest spacing.

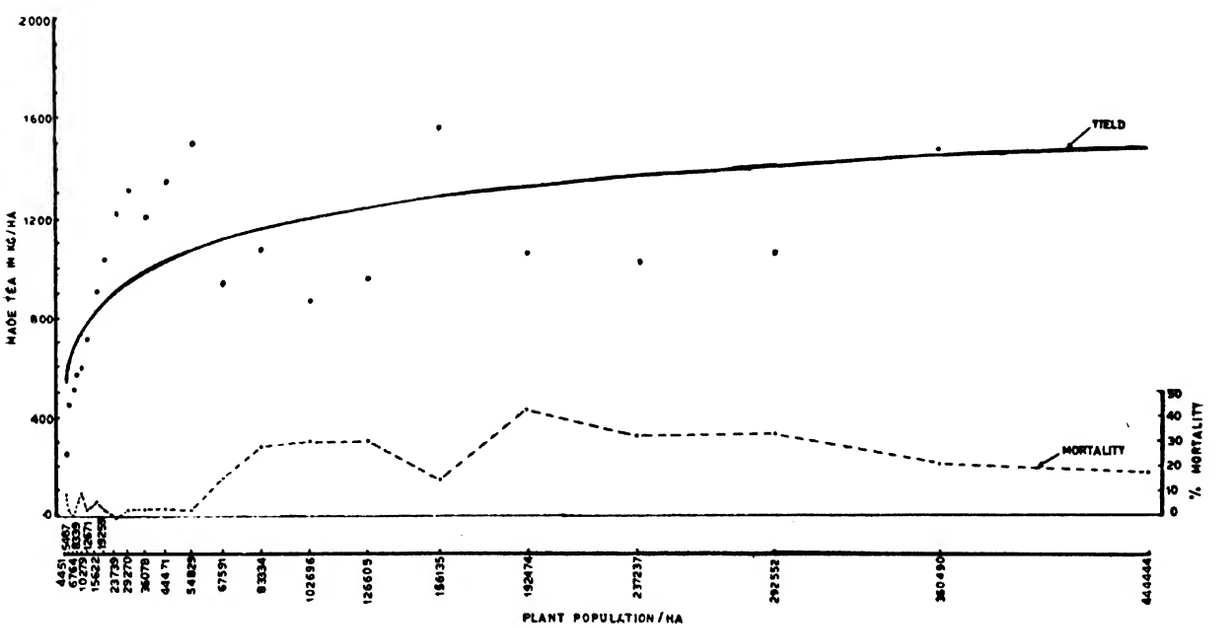
Another trial (B. 8/2), started in 1966, has six plant-to-plant spacings (60 cm, 75 cm, 90 cm, and 120 cm and doubletons at 75 cm and 90 cm) with a constant row spacing of 120 cm. Khorijan tea was used in this trial.

Table 3.2. *Effect of different spacings on the yield of jat tea (made tea kg/ha)*

Spacing (cm)	Plant population/ha	1974 D.S.	1975 M.S.	1976 L.P.
120 × 120	6,944	1505	1352	1219
120 × 90	9,259	1635	1422	1255
120 × 90 (doubleton)	18,518	1703	1438	1380
120 × 75	11,111	1562	1374	1208
120 × 60	13,888	1682	1499	1437
120 × 75 × 75	13,675	1844	1587	1547
L. S. D.(at 5% Level)	—	155	135	186
C. V. (%)	—	6.2	6.2	9.2

Yield responses to spacings were different in 1974, 1975, and 1976 (Table 3.2). The 120 cm × 75 cm × 75 cm spacing gave significantly higher yield over 120 cm × 60 cm in 1974 but these two treatments were at par in 1975 and 1976. The 120 cm × 75 cm ×75 cm spacing was always significantly superior to 120 cm × 120 cm, 120 cm × 90 cm, and 120 cm × 75 cm spacings. There was no significant yield difference between 120 cm × 90 cm (doubleton) and 120 cm ×75 cm × 75 cm spacings in all the years.

In another experiment (B. 104) which was started in 1957, the effects of five spacings (120 cm × 120 cm,



Fig

150 cm × 98 cm, 150 cm × 75 cm, 150 cm × 60 cm and 120 cm × 60 cm) on the yield of two jats of tea at three levels of nitrogen were studied. There were no significant yield differences between various spacings from 1974 to 1976.

An experiment (B. 32.2) adopting a new design (systematic fan design) covering 23 spacings ranging from 15 cm to 150 cm was planted in July 1974. The plants were damaged by hail in early 1975 and could not be decentered till January 1976 because of low starch reserves. They were allowed to grow freely in 1975 and decentred in January 1976.

The mean yield of 1976 under different plant population treatments along with the vacancy count is graphically represented in Fig. 1. The relationship between yield and plant population above 55,000 plants per hectare was not consistent. This inconsistency at high population levels is most likely due to severe interplant competition resulting in higher mortality.

Various equations were used to find out the relationship between plant population and yield. From these studies it was found that the equation $Y = a + b \log X$ gave the best fit (Fig 1) so far. This relationship signifies that as the plant population per unit area (X) increases the rate of increase in yield per unit area gradually decreases. There was virtually no increase in yield beyond 55,000 plant population/ha (Fig 1.). However, it is expected that this relationship may change with the age of the plants. Further studies are being continued.

Plucking

In one trial (B 112.1/1) the effect of different methods of plucking on the yield of jat tea is being studied since 1971. The effect of the following treatments were studied till 1975 :(1) pluck black to *janam*, (2) pluck standard leaf, no breaking back,(3) pluck standard leaf, and break back to *janam*, (4) pluck standard leaf over fish leaf, and no breaking back, and (5) pluck standard leaf over fish leaf, and break back to level off. From 1972 to 1974 plucking black to *janam* (black plucking) gave significantly higher yield over all other treatments except plucking method No. 3 in 1972 and 1974. (*c.f.*, Annual Report 1975-76, p. 15). In the light pruned year of 1975, all treatments were plucked uniformly as per the Tocklai standard method. No significant deleterious effect of black plucking done from 1971 to 1974 was observed on the 1975 yield.

In 1976 the experiment was modified to study the effect of continuous and intermittent standard and black plucking systems on unpruned tea. The plucking season was divided into three *i.e.*, beginning of the season to May, June to September, and October to November. Standard and/or black plucking in these three periods were done continuously or intermittently in various combinations. Results indicated that there was no significant difference in yield between these various treatments. The experiment is being continued.

Plant Nutrition

A number of experiments to study the response of tea to different plant nutrients are being conducted at Borbhetta. The results of some of these experiments are briefly discussed below :

Nitrogen

In one factorial experiment (B. 8/1), initiated in 1966, three nitrogen levels, (100, 200, and 300 kg/ha) were included along with four spacings and two clones. The data on the main effects of nitrogen levels (Table 3.3) showed that there was no yield difference between 200 and 300 kg N/ha from 1970 to 1972 but both these levels gave significantly higher yield than 100 kg N/ha in 1971 and 1972. However, 300 kg/ha level was detrimental to yield in 1973, and this was confirmed statistically since 1974. 200 kg N/ha level gave significantly higher yield than 100 kg/ha in 1971 and 1972, but it was at par with 100 kg N/ha in 1973, 1974, and 1975. In 1976, 100 kg N/ha gave significantly higher yield than the two higher levels of nitrogen.

Table 3.3. *Effect of different levels of nitrogen on the yield of tea (made tea kg/ha)*

Nitrogen level (kg/ha)	1970 D.S.	1971 M.S.	1972 L.S.	1973 L.P.	1974 D.S.	1975 M.S.	1976 L.P.
100	1098	1336	2148	1484	1990	1897	1954
200	1331	1690	2516	1544	2066	2028	1633
300	1360	1628	2438	1289	1659	1565	1125
L.S.D.(at 5% level)	N.S.	267	262	N.S.	226	200	181
C.V. (%)	27.3	23.3	15.0	22.1	16.1	14.8	16.0

In a different experiment (B. 104) the effect of three levels of nitrogen (90, 135, and 180 kg/ha) on two *jats* of tea (Betjan and Gaurishankar) at five different spacings is being investigated. After an initial boost in yield in 1961 and no increase during 1962 to 1968, the higher levels of nitrogen were found deleterious since 1969.

Table 3.4. *Effect of three levels of nitrogen on yield of tea (made tea kg/ha)*

Nitrogen level (kg/ha)	1972 L.P.	1973 D.S.	1974 M.S.	1975 M.P.	1976 U.P.
90	1462	1289	1361	598	1875
135	1370	1174	1343	540	1764
180	1276	1117	1251	481	1591
L.S.D. (at 5% level)	59.0	50.2	56.3	31.4	87.0
C. V. (%)	9.6	9.4	9.6	13.0	11.1

The results of 1972 to 1975 (Table 3.4) showed that 90 kg/ha level of nitrogen gave significantly higher yield than 135 and 180 kg/ha levels in all the years except

1974 when 90 kg/ha and 135 kg/ha were at par. Application of 180 kg/ha reduced the yield significantly in all the years.

In another factorial experiment under unshaded condition (B. 5.1), the response of Tingamira jat tea to four levels of nitrogen, two levels of phosphate and two levels of potash is being studied since 1961. The results (Table 3.5) indicated that 150 kg/ha level had deleterious effect on the yield of tea.

Table 3.5. *Effect of four levels of nitrogen on the yield of tea (made tea kg/ha)*

Nitrogen level (kg/ha)	1972 L.P.	1973 U.P.	1974 U.P.	1975 L.P.	1976 U.P.
0	1154	1153	1234	798	1353
50	1348	1522	1765	1160	2076
100	1148	1434	1808	1093	2091
150	854	1135	1549	819	1786
L.S.D. (at 5% level)	87	88	109	88	145
C.V. (%)	10.9	9.4	9.6	12.7	11.2

The experiments with nitrogen suggest that the tea responds well only upto a certain level of nitrogen application beyond which the response is negative.

Phosphorus

A factorial experiment (B. 105) is being conducted since 1960 to study the response of TV 2 clone to four levels of P_2O_5 applied as single superphosphate. The data (Table 3.6) indicated that application of P_2O_5 did not affect the crop yield significantly in all but three years (1970, 1974, and 1976). In 1970, P_2O_5 application tended to reduce the yield. Later, P_2O_5 appeared to enhance the yield, but not significantly. In 1974, and 1976 there was significant response upto 90 kg/ha.

Table 3.6. *Effect of different levels of phosphate on the yield of tea (made tea kg/ha)*

P_2O_5 (kg/ha)	1970 L.P.	1971 D.S.	1972 M.S.	1973 L.P.	1974 D.S.	1975 M.S.	1976 L.P.
0	1588	1708	2467	1697	1865	1786	1022
45	1576	1744	2562	1730	1977	1824	1231
90	1493	1790	2675	1796	2067	1826	1410
180	1374	1680	2594	1706	1975	1711	1446
L.S.D. (at 5% level)	109	N.S.	N.S.	N.S.	117	N.S.	139
C.V. (%)	10.2	10.2	8.6	8.6	8.4	11.7	15.3

This reversal in the trend of phosphorus response could be attributed to the effect of chemical weed control which eliminates weed competition and encourages production and development of a mass of surface feeder roots. Another possible reason for the increase in response to phosphorus is the interaction effect of zinc which is being applied as zinc sulphate since 1970. Such interaction effects are not uncommon in other crops.

In another experiment (B. 23/3) conducted on Tingamira jat planted in 1961, the effect of mulch and weed control on the response to various levels of phosphorus application is being investigated since 1973.

Table 3.7. *Effect of phosphorus, mulch and chemical weed control on the yield of tea (made tea kg/ha)*

Treatment	1973 L.P	1974 D.S.	1975 L.S.	1976 L.P.
Phosphorus (kg/ha)				
0	1468	2140	2031	1623
50	1474	2214	2047	1605
100	1463	2186	2048	1588
150	1506	2181	2084	1631
200	1480	2182	2108	1661
L.S.D. (at 5% level)	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.5	7.0	7.9	6.8
Mulch				
No. mulch	1480	2162	2017	1592
Guatemala mulch	1477	2200	2110	1652
Weed Control				
Cheeling	1483	2173	2036	1584
Chemical Weed Control	1473	2188	2091	1660
L.S.D. (at 5% level)	N. S.	N.S.	47	55
C. V. (%)	5.6	5.7	5.0	7.6

There were no significant yield differences between the various levels of phosphorous application, mulching and weed control treatments in 1973 and 1974 (Table 3.7). In 1975, mulching and chemical weed control treatments were significantly superior to no mulching and *cheeling* respectively. In the light pruned year of 1976, the effects of mulching and weed control and the interaction between the two factors were found significant. Mulching and weed control gave significantly higher yield over no mulching and cheeling. With regard to interaction it is interesting to note (Table 3.8)

Table 3.8. *Effect of chemical weed control with and without mulch on yield of tea (made tea kg/ha)*

Treatment	No. mulch	Mulch
Cheeling	1528	1640
Chemical weed control	1656	1664
L.S.D. at 5%		78.5
C.V. %		7.6

that application of mulch in cheeled plots gave significant increase in yield but there was no such beneficial effect of mulching in the herbicide treated plots. This suggests that yield increase due to chemical weed control is equal to the yield increase obtained by mulching combined with cheeling in mature tea.

Potassium

The response of clonal tea (TV 2) to potassium was studied in an experiment (B. 105) involving four levels of K_2O and P_2O_5 (discussed earlier in response to phosphorus). Potassium was applied since 1960 at 0, 45, 90, and 180 kg/ha.

The data (Table 3.9) indicated that there was significant response to K_2O upto 45 kg/ha in the pruned years but in the skiffed years 180 kg potash/ha gave higher yield than 45 kg/ha.

Zinc

In one experiment (B. 108/1.2) the effect of zinc is being studied since 1970 on Tingamira jat tea planted

Table 3.9. *Effect of different levels of K_2O on the yield of tea (made tea kg/ha)*

K_2O (kg/ha)	1973 L.P.	1974 D.S.	1975 M.S.	1976 L.P.
0	1495	1671	1555	1048
45	1779	1988	1780	1293
90	1803	2054	1880	1349
180	1854	2171	1933	1420
L.S.D. (at 5% level)	106	117	149	139
C.V. (%)	8.6	8.4	11.7	15.3

in 1958 and grown under medium shade. Zinc was applied as zinc sulphate at 24 kg/ha and the results showed that, except in 1971, there was no significant response to zinc.

In another experiment (B. 1A/2.1) where clonal tea (TV 9) was planted in 1964, a study is being conducted since 1973 to determine the level, method, and frequency of application of zinc on mature tea. Zinc was applied to the foliage or soil at two rates (12.5 and 25.0 kg/ha) and the application was given every year and once in three years. No significant yield differences amongst the treatments were observed in any of the years.

Long term yield trial of Tocklai clones

A long term trial (B. 40/1) was initiated in 1966-67 with various clones to compare their yield performance. This trial had *Indigofera teysmanii* as shade tree. Different clones were planted from 1966 to 1971.

Table 3.10. *Yield of different clones and two seed stocks (made tea kg/ha)*

Clone	Year of planting	Yield 1976 (LP)	Clone	Year of planting	Yield 1976 (LP)
TV 1	1966-67	1653	TV 13	1966-67	1855
TV 2	1966-67	1360	TV 14	1966-67	1810
TV 4	1966-67	1719	TV 15	1967-70	1690
TV 6	1966-67	1463	TV 16	1966-70	1914
TV 7	1966-67	1669	TV 17	1967-69	1859
TV 8	1966-67	1594	TV 18	1969-70	1905
TV 9	1966-67	1748	TV 19	1969-71	2231
TV 10	1966-67	1896	107/2	1970-71	1717
TV 11	1966-67	1855	Stock 450	1967-71	1686
TV 12	1966-67	1739	Betjan	1966-67	1590
L. S. D. (at 5% level)		308			
C. V. (%)		12.4			

Yield data (Table 3.10) indicated that TV 19 had given significantly higher yield over all other clones tested. TV 16 and TV 18 also gave significantly higher yields over clones TV 2, TV 8, and Betjan which showed poor performance.

WEED CONTROL

Weed competition in young tea

A field experiment (No. 3/76) was laid out in the first week of April 1976 on five months old tea (TV 18) to determine the critical period of weed competition in young tea. The periods during which weeds were removed (at monthly interval) were April-June, July-September, October-December, January-March, April-September, October-March and April-March.

The results indicated that when weeds were not removed from April to June, the most conductive period for weed growth, weed biomass was five times greater in July. Most of the weeds like *Borreria hispida, Paspalum conjugatum, Scoparia dulcis, Digitaria sanguinalis, Cyperus sp.* grow actively (in that order of predominance) from April to June and this active growth period, when left unchecked, also extended till September. However, once weeds were removed in April and May, there was very little growth in the subsequent months.

Removal of weeds resulted in increased branching. Greater branching and green leaf yield were obtained when the plot was weed-free from April to September and very little further increase in branching and yield was observed when weeds were controlled all through the year. Weed removal during July-September also showed an immediate beneficial effect.

These results suggest that weed competition is critical early in the season (April to September) and delay in weed control during this period would affect branching, growth and yield of young tea, adversely, and that good weed control is vital for the establishment of newly planted tea.

Chemical weed control in nursery

1. New herbicides: Several new herbicides were compared with Simazine for weed control in tea nursery. The herbicides included in this trial (No. 1/76) were Simazine, Atrazine, Lasso (alachlor), Machete (butachlor), Basalin, Kerb (RH-315), Probe (methazole), Destun (MBR-8251) and Ronstar (oxidiazon). These herbicides were applied in the nursery at 2 kg/ha (rates of all herbicides are expressed as kilograms active ingredient per hectare) on April 22, 1976, three weeks before planting of clonal (TV 18) cuttings. Second application was done on the soil after hand weeding at the same rate when weed coverage in the plot exceeded 50 percent, and this period varied with each herbicide.

All herbicides controlled weeds effectively after the initial application. Lasso, Machete, Basalin, Destun and Kerb lost 50 percent of their efficacy in $2\frac{1}{2}$ to 3 months after the initial preplanting application. Kerb lost its effect much more rapidly than the others. Simazine, Atrazine, and Probe persisted for $3\frac{1}{2}$ months. Ronstar showed activity for more than $4\frac{1}{2}$ months.

Callus formation and rooting of cuttings were severely inhibited by Destun, while Kerb showed moderate inhibition. Root formation was considerably activated by Ronstar, Basalin, Machete, and higher rates (3 kg/ha) of Simazine and Atrazine. Destun, Kerb, and Lasso inhibited shoot formation. When applied at post-emergence, Atrazine and Probe severely injured the seedlings. Work on these herbicides is being continued.

Herbicide combinations: All the above new herbicides effective on annual grasses, were tank-mixed (at 1 kg/ha rate) with Simazine or Atrazine (2 kg/ha rate),

the predominantly broadleaf herbicides, to determine suitable herbicide combination(s) for control of a wide range of annual weeds in the nursery (trial No. 2/76). The herbicides were first applied on April 23, three weeks before planting of TV 18 clone. The second application was done at the same rate about four months after the first one as almost all the trestments had weed coverage of more than 50 percent.

Tank mixing of new herbicides with Atrazine caused (but not with Simazine) inhibition of callous formation and shoot formation. Simazine + Destun lost 50 percent of activity after only two months, while Atrazine + Lasso and Simazine + Kerb combinations lost their effects faster than the remaining treatments. Application of Ronstar or Basalin with either of the triazines showed greater promise. Simazine + Probe and Atrazine + Probe combinations showed greater toxicity to plants than the other combinations when applied second time at postemergence. Tank mixing of Basalin with either Simazine or Atrazine showed very little postemergence toxicity. Further research is underway to select suitable herbicide combination(s).

Control of individual weeds

1. *Imperata cylindrica and Paspalum conjugatum :* An experiment (No. 4/76) was laid out on 29 May, 1976 in six-row plots in unshaded six-year old tea infested with these two grasses. Mechanical treatments and herbicides were applied three times in the year, 29 May, 19 July and 9 September. In case of sequential treatment, Roundup (glyphosate) was applied initially and followed twice later by 2,4-D, Dalapon or Gramoxone.

Roundup was significantly superior to all other treatments in controlling *Imperata* and *Paspalum*. There was no significant difference whether it was applied (0.4 kg/ha) only once initially or three times continuously. After the initial Roundup application the follow up applications twice later with Dalapon or Gramoxone caused no additional benefit on the control of both perennial grasses. Dalapon applied thrice was moderately effective on both grasses. The initial effect of Gramoxone was rapidly lost and control was poor. Probe showed only a partial effect on both weeds. Fork hoeing was significantly more effective than cheeling and comparable to Dalapon.

Borreria hispida : As *Borreria* (*Bagracote*) was also found in the field trial (No. 4/76) on *Imperata* and *Paspalum*, the effect of various treatments on this broadleaf weed was also studied. Probe, generally a premergence herbicide but applied at postemergence in this trial, was most effective on *Borreria;* it almost completely eliminated this weed after the second and third applications. Roundup showed good control, but the follow up with 2,4-D was significantly superior than the follow up with Roundup. Gramoxone showed only a slight effect.

3. *Setaria palmifolia :* Pot culture experiments (No. 6/76) were conducted to find out suitable herbicides for effective control of *Setaria palmifolia.*

Roundup at 1.2 kg/ha completely inhibited the growth of *Setaria* by second week itself. 2,4-D had no effect while Dalapon, Probe and Asulox 40 (asulam) controlled this perennial grass only partially. Gramoxone controlled this grass for a short time. 2,4-D (0.8 kg/ha) markedly enhanced Roundup activity indicating a possible synergistic interaction. Similarly, 2,4-D also enhanced Gramoxone effect when both were applied as tank mix, the residual effect of the combination being greater than when Gramoxone was applied alone.

To further study this synergism, Roundup was applied at 0.4, 0.6, and 0.8 kg/ha and tank mixed with 0.4 or 0.8 kg/ha of 2,4-D. Roundup was extremely effective even at the lowest rate of 0.4 kg/ha. Roundup + 2,4-D combination at 0.4 + 0.4 kg/ha was as effective as Roundup alone at 0.8 kg/ha (Table 3.11).

Table 3.11. *Synergistic effect of Roundup and 2,4-D combination on the control of Setaria palmifolia*

Herbicides	Rate (kg/ha	Weed control rating* days after spraying 3	5	7	9	14	21	35
Roundup	0.2	0.0	1.0	3.0	5.0	6.0	8.2	9.3
	0.4	1.0	3.0	6.0	7.5	9.0	9.7	10.0
	0.6	1.3	4.0	7.0	9.0	10.0	10.0	10.0
	0.8	2.5	5.3	8.0	9.5	10.0	10.0	10.0
2,4-D	0.8	0	0	0	0	0	0	0
Roundup + 2,4-D	0.4 0.4	3.0	6.8	8.3	9.5	9.8	9.8	10.0
Roundup + 2,4-D	0.4 0.8	3.0	7.0	9.0	9.5	10.0	10.0	10.0
Roundup + 2,4-D	0.6 0.4	5.0	8.0	9.5	10.0	10.0	10.0	10.0
Probe	2.4	0.5	0.5	2.0	2.0	3.0	4.5	4.5
Probe + 2,4-D	1.6 0.8	1.0	1.0	2.3	3.5	5.3	6.3	5.2
Probe + 2,4-D	2.4 0.4	1.0	1.0	2.0	2.5	3.0	4.5	3.7
Roundup + Probe	0.4 1.2	1.0	1.0	2.0	2.5	3.0	4.8	4.0
L.S.D.(at 5% level)					0.4			
C.V. (%)					9.8			

*Weed rating was done in the scale 0 (no control) to 10 (100% control)

Interestingly, Probe reduced Roundup effect very markedly, bringing the level of weed control down to that caused by Probe alone, thus suggesting a possible antagonistic interaction between the two.

4. *Polygonum chinense :* A field experiment (No. 7A/76) was conducted in a nearby tea estate to determine suitable herbicide(s) for its control. Roundup applied at 2.4 kg/ha had almost completely eliminated this weed while at 1.2 kg/ha fairly good control was observed. Probe and Dalapon showed moderate effect which did not last very long. Fernoxone (2,4-D sodium salt) 0.8 kg/ha was only partially effective, but Weedar 96 (amine formulation) was more effective. Gramoxone was least effective. Asulox-40 at 2.8 kg/ha gave fairly good control.

5. *Polygonum Perfoliatum* : Another estate trial (No. 7B/76) was conducted on *Polygonum perfoliatum* during the year in a manner similar to that described in case of *P.chinense*. Roundup (0.8 and 1.2 kg/ha), Probe (3.2 kg/ha) and Weedar 96 (0.7 kg/ha) controlled this weed satisfactorily.

6. *Scoparia dulcis* : The present study is a continuation to the two trials conducted last year (vide Annual Report 1975-76). In this year's trial Probe, Roundup and Actril D (ioxynil) were applied on sleeve grown plants alone or in combination or sequentially with Gramoxone. In sequential application, Roundup, Probe and Actril-D were applied four weeks after the initial paraquat application.

Probe, at 2.4 kg/ha, showed excellent activity on *Scoparia*, while Roundup caused only a moderate effect at 0.8 and 1.2 kg/ha. Tank mixing of Probe or Roundup, or even Actril D with Gramoxone had greater effect than when applied alone. This indicated that there was enough time for these translocated herbicides to get absorbed by the plant and reach the root system before Gramoxone could kill the vegetative parts of the plant, thus hindering further regrowth. Application of Probe, Roundup or Actril-D four weeks after Gramoxone application showed no particular advantage over their application in combination with Gramoxone.

Enhancement of herbicide activity

1. Effect of fertilizer additives on Roundup activity : In this pot culture study (No. 8/76) the effect of tank mixing of very low rates of ammonium sulphate and urea on Roundup activity on *Imperata cylindrica* was determined. Fertilizers were added at 2, 4, and 6 kg/ha to Roundup solution.

Addition of ammonium sulphate even at as low a rate as 2 kg/ha markedly increased Roundup activity at 0.4 kg/ha. Addition of 4 kg/ha of ammonium sulphate to 0.4 kg/ha of Roundup enhanced the control of *Imperata* further, the final effect (at five weeks) being as good as at 0.8 kg/ha of Roundup alone. Urea, however markedly reduced Roundup activity.

2. Effect of rain wash and Triton AE on Roundup activity : In another pot culture trial (No. 9/76), rainfall (1.25 cm) was simulated at different periods after Roundup application. Triton AE was added at 0.06% to Roundup (0.4 kg/ha) solution to determine whether this sticking and spreading agent would prevent the rainwash of herbicide spray off the foliage of *Imperata cylindrica*.

A rain-free period of at least four hours was required after Roundup application for a reasonably good control of *Imperata*. When there was no rainfall, addition of Triton AE had no effect on Roundup activity. The sticker reduced rainwash of Roundup only when rain occurred two hours or later after application.

Effect of spacing on weed infestation and intensity

A study on weed infestation and intensity as influenced by different spacings was made in the systematic fan design experiment (B. 32.2) covering a spacing range of 15 cm to 150 cm in 23 ares. Weed counts were taken thrice in the year from two quadrats placed randomly at five spacings. Roundup (0.4 kg/ha) was applied after each weed counting.

At closer spacings there was less weed infestation but as the spacing was widened more weed growth was observed. Maximum weed growth was found at the widest spacing which offered more sunlight and favourable growing condition to weeds. The weed species predominantly found were *Borreria hispida*, *Cyperus sp.*, *Mullago pentaphylla* and *Digitaria sanguinalis*.

Effect of herbicides on quality of tea

In apermanent herbicide trial (B. 27), Gramoxone (0.6 kg/ha), Probe + Gramoxone (3.2 + 0.15 kg/ha), and 2,4-D + Dalapon (0.8 + 3.0 kg/ha) were applied continuously every year. The results indicated that none of the herbicidal treatments affected the strength of liquor, and quality and valuation of C.T.C. tea.

Check Testing

A number of new Dalapon and 2,4-D formulations have been check tested during the year. The following have received certification of approval for use in tea.

1. **Dalapon formulations**
   (a) Asadapon of Assam Chemical Industries.
   (b) Dalapon of B. D. Khaitan & Co.
   (c) Mico-80 of Mysore Insecticides Co. Private Ltd.,

2. **2, 4-D formulations**
   (a) Phenamin of New Industrial Chemicals.
   (b) 2, 4-D sodium salt of B. D. Khaitan & Co.

3. **Paraquat formulations**
   (a) Paraquat 24% of Krishi Rasayan.
   (b) Paraquat 24% (Starquat) of Shaw Wallace & Co

These two formulations were based on paraquat dimethyl sulphate. Interim certificates of approval were given only to enable the sale of the present stock by these two companies.

Quality testing of herbicides

Eighteen samples of 2,4-D, dalapon, paraquat, diuron, and simazine formulations received from 14 estates were tested for quality. Out of six Gramoxone samples three were substandard, and out of five dalapon samples two were substandard. All the others i.e., one sample each of 2,4-D sodium salt, Weedar 96 (2,4-D amine), and Hexuron (diuron) and four samples of Tafazine (simazine) were normal.

Soils and Meteorology

Tea soils receiving adequate quantities of phosphate (400-200 kg P_2O_5/ha) over long periods have better ability to release phosphate in available form to the plant, thereby indicating the necessity of phosphate application as future investment. Further, under exhaustive cropping conditions the uptake of residual phosphate by a test crop from soils adequately manured for a long time has been found to be much higher than from soils to which phosphate has been freshly applied.

Cumulative potash uptake by a test crop under conditions of exhaustive cropping has been found to be highly correlated with the available potash content of the soils from all regions of North East India. Q/I ; (intensity/capacity of soil K) relationships worked out for different regional soils suggest that our soils have low fixation capacity for potash and the potassium buffer capacity (P.B.C.) of these soils is of the same order. Thus soil potassium release pattern is unlikely to vary between the different regions, thereby indicating that soil potash and crop correlation test should yield the same type of results both in Assam and West Bengal.

Young tea plants grown under three moisture regimes (Field capacity or F.C., $\frac{3}{4}$ th F. C. and $\frac{1}{2}$ F.C.) and receiving five levels of potash (0 to 200 kg K_2O/ha) were used for measuring diffusive resistance of stomata and leaf water potential (the two sensitive indices for determining leaf moisture status). From both the measurements it can be said that higher soil dressings of potash (100-200 kg K_2O/ha) applied before the onset of drought may reduce the susceptibility of plants to drought, since these measurements provide evidences on the usefulness of potash manuring in increasing the water use efficiency by plants.

A survey of the available zinc content of the tea soils of North East India shows that most of the soils examined have a zinc content of between 3 and 27 p.p.m. The soils that fall within the critical limit between 1·5-3·0 p.p.m. (considered as boundary between Zn responsive and non-Zinc responsive soils) are rather limited, ranging between 1-7 per cent in various regions. It has been found that the internodes of tea leaves accumulate zinc to a large extent (mean Zn content of internode being 83 p.p.m. against 42 p.p.m. of the leaves), the implication of which in Zn nutrition of tea is now being examined. Further, zinc content of leaves decreases in a pronounced way from morning till afternoon whereas no change in the concentration of internode zinc takes place from morning till afternoon, indicating thereby "luxury consumption" of zinc in the leaf internodes.

Tea lands of five circles in Nowgong and Sibsagar districts have been classified for the first time for their safe use and protection against erosion.

Attemps have been made to obtain quantitative information on the occurence of high ground water table during monsoon in thirteen project sites for establishing criteria for the control of ground water table besides verifying probable occurence of "perched water table" and underground "artesian pressures". Besides, a system of sub-soil pipe drainage has been tried out in three project sites to examine the feasibility of effective ground water table control through this method than by the conventional open drains. A large-scale pumping experiment has been laid out in an estate with limited outfall in order to find out the possibility of keeping the ground water table sufficiently low in open ditches and pipe drains during high rainfall periods.

STUDIES ON SOIL PHOSPHATE

Exhaustive cropping trial

Exhaustive cropping trial with *Pennisetu pedicellatum* has been continued throughout the year and another seven harvests of grass have been taken at monthly intervals. As in the previous years (Ann. Sci. Rpt. for 1975-76, pp. 22-23) phosphate uptake by the grass and exchangeable and water soluble phosphates of the soil have been determined on each occasion of harvest. The grass has not yet shown signs of exhaustion although fourteen harvests have so far been taken.

The relation of cumulative phosphate uptake by the test crop with the levels of application of phosphate (either freshly added or residual) as reported last year for seven harvests remains unaltered at the end of fourteen harvests. The main conclusions are :

(i) Phosphate uptake by grass increases linearly with increasing levels of phosphate application in soils from different regions in spite of their characteristic differences.

(ii) The quantities of phosphate taken up by the grass, however, varies from soil to soil, the trend so far obtained being Darjeeling > Dooars = North Bank > South Bank soils.

(iii) The uptake of residual phosphate from soils manured for a long time has been found to be consistently higher throughout the cropping period than from soils to which phosphate has been freshly applied.

(iv) Data upto fourteen harvests support the conclusion reported last year that both water soluble and exchangeable soil phosphate measurements can be relied upon for prediction of phosphate uptake by the grass. The relationships between phosphate uptake by the test crop and water soluble as well as exchangeable phosphate contents of soils are shown in Figs. 1 and 2 respectively. Both water soluble and exchangeable phosphate fractions of soils being highly correlated (r^2 0.88, P <0.001), measurement of exchangeable phosphate fraction has been accepted for routine soil testing in preference to water soluble phosphate measurement which is a time consuming and tedious operation.

Phosphate adsorption index of tea soils

A method has been standardised for characterising our soils in respect of phosphate sorption capacity. For this purpose fifteen soils were used, of which eight belonged to different tea areas of the region and the remaining seven were drawn from long-term experimental fields. Phosphate adsorption isotherms covering a wide concentrationrange of (1×10^{-4} to 5×10^{-4} M phosphate)

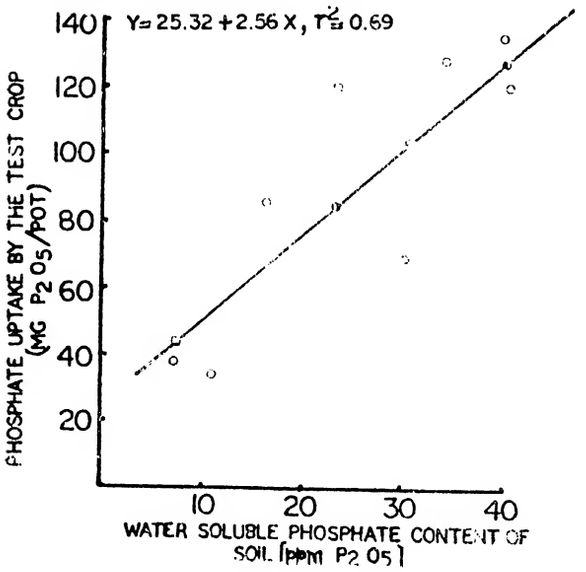


Fig 1. Relationship between phosphate uptake by the test crop and water soluble phosphate content of soil.

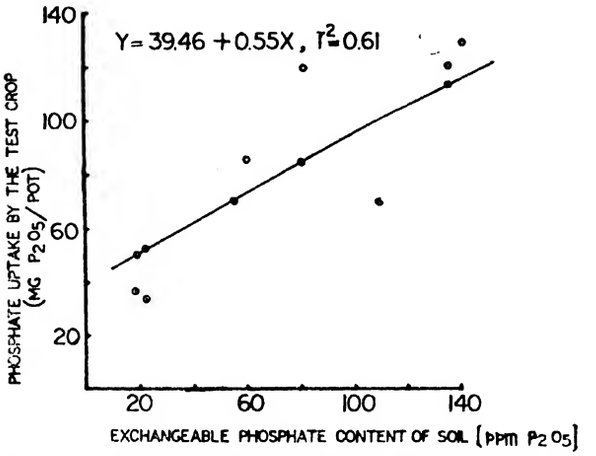


Fig 2. Relationship between phosphate uptake by the test crop and exchangeable phosphate content of soil.

were determined for these fifteen soils at room temperature by the standardised method. Several physico-chemical parmeters have been calculated from the adsorption isotherms to find out their interrelationship and ultimately to obtain a sorption index for characterising and comparing the tea soils. Some of the results are given in Table 4.1.

Table 4.1. *Comparison of single-value sorption indices from isotherms with conventional anion exchange capacity measurement*

Source	Past treatment (P_2O_5 kg/ha)	Texture	Exchangeable phosphate mg/ 100 g soil	Sorption maximum (Pmax) mgP/100g soil	Bonding energy of soil for P ($K \times 10^{-5}$)	Phosphate buffering capacity (PBC $\times 10^{-4}$)	Anion exchange capacity m.e. per cent
From 16 yrs manurial expt. B.23/3	0	Sandy loam	3.69	8.45	103	6	11.6
,,	50	,,	4.35	22.90	117	4	19·2
,,	100	,,	4.76	51.20	67	24	20·8
,,	150	,,	6.20	99.50	17	39	25·6
,,	200	,,	6.23	86.45	19	52	25·6
Dooars	Virgin soils	Loamy Sand	4.81	214.52	26	256	9·89
Darjeeling	,, ,,	Sandy loam	4.90	136.62	94	108	1·90
South Bank	,, ,,	Loam	0.96	205.78	34	167	3·08
-do-	,, ,,	Silty clay	1.23	204.08	104	331	1·86

From above table the following conclusion can be drawn :

(i) With long-term manuring of phosphate physico-chemical parameters like sorption maximum, phosphate buffering capacity, anion exchange capacity and exchangeable phosphate increases while bonding energy of soils for phosphate decreases.

(ii) The anion exchange capacity does not vary appreciably between 50 and 200 kg P_2O_5/ha application rates, whereas sorption maximum (Pmax) increases significantly with increasing rates of P applied up to 150 kg P_2O_5/ha, thereby suggesting the usefulness of determining adsorption isotherms for finding out the limit to which sorption can proceed in our soils.

(iii) Phosphate buffering capacity (PBC) does not change appreciably at low levels of phosphate application whereas between 100 to 200 kg P_2O_5/ha application rates the increase of PBC is linear. During the process of withdrawal of phosphate by crop, the greater the PBC values the higher will be the ability of the soils to maintain the concentration of phosphate in soil solution at the root interfance. This information cannot be gained from measurements of either exchangeable phosphate or anion exchange capacity.

(iv) Adsorption isotherms of soils belonging to the different texture gronps and regions, so far determined, show that the limit to which P sorption can proceed is about 200 mg P/100 g soil or about 9,000 kg/ha P_2O_5.

It is however, early to point out the usefulness of determining phosphate adsorption isotherms for purpose of comparing and characterising regional soils of different series and parent materials. However, an important practical information can be gained from this study, i.e., plots receiving adequate quantities of phosphate over long period have better ability to release phosphate in available form to the plant, thereby indicating the necessity of phosphate application as future investment.

STUDIES ON SOIL POTASH

Influence of potash on drought resistance

The influence of potash manuring on the moisture status of the leaves of young clonal tea maintained at three moisture regimes was investigated during February, 1976 to July 1977. The experimental layout comprises of moisture at three levels, i.e., Field Capacity (F.C.), 75 p.c. of F.C. and 50 p.c. of F.C. as main treatments and five levels of potash, i.e., 0, 50, 100, 150 and 200 kg K_2O/ha as sub-treatments. There are six replications of which three replications have been used for the purpose of this study. Moisture regimes have been maintained all throughout the study by supplementing the loss of water due to evapo-transpiration twice every week, as and when indicated by the calibrated gypsum blocks inserted in each pot.

For purpose of determining moisture status of leaf, two sensitive indices have been used namely, diffusive resistance (sec cm^{-1}) of stomata and leaf water potential (bar). Diffusive resistance being an expression of the functional opening and closing of leaf stomata indirectly gives a measure of transpirational loss whereas leaf water potential indicates the degree of turgidity of the leaf cells.

(a) Diffusive resistance of leaves

The measurements were taken using a diffusive resistance autoporometer, which was calibrated initially by placing a known resistance between the sensor cup and water saturated filter paper (provides 100 % R.H.). Time ($\triangle t$) required to increase the humidity of the sensor between preselected points (in our case 16 to 24 p.c. saturation), was recorded at each known resistance (R) employed. At the end $\triangle t$ was plotted against R to obtain the standard curve. Taking help of this curve field $\triangle t$ values were converted to diffusive resistance data (sec cm^{-1}).

Following calibration, the position of the leaf and the time of the day were standardised for recording diffusive resistance data. For this purpose two clones (TV_1 and TV_7) were used, where resistance measurements of third to eighth leaves were recorded at 9 a.m., 12 noon and 5 p.m. Resistance increased slightly with the age of the leaf, but not beyond the sixth leaf position. However, diurnal variation of leaf resistance was considerable, which increased remarkably between 8 a.m. and 5 p.m. For example the resistance of sixth leaf of clones TV_7 and TV_1 increased by about seven and three times respectively from 8 a.m. to 5 p.m. after which it did not show marked variation until about 9 p.m. Hence for measurement of resistance of the experimental plants sixth leaves were used at 5 p.m. Results are given in Table 4.2:

Table 4.2. *Effect of potash on diffusive resistance (sec cm^{-1}) of plants at different soil moisture status.*

Levels of potash (K_2O, kg/ha) (K)	Soil moisture regime (M)			Mean
	Field Capacity (FC) (M_0)	75% of F.C (M_1)	50% of F.C (M_2)	
0 (K0)	19.08	30.39	28.00	25.82
50 (K1)	18.37	34.40	44.33	32.37
100 (K2)	21.21	35.50	48.92	35.21
150 (K3)	22.86	35.63	48.39	35.63
200 (K4)	26.79	38.57	54.23	39.31
Mean	21.33	34.90	44.77	

C. V. 13% C.D. at 5% (M) 3.12
" " " (K) 4.02
" " " (M × K) 6.93.

Statistical analysis of data shows the effects of moisture, potash and their interaction to be highly significant ($P < 0.01$). From the interaction table given above the following conclusions can be drawn :

(i) As soil moisture stress increases, the diffusive resistance of leaf stomata towards transpirational losses also increase.

(ii) Potash increases diffusive resistance of leaf stomata resulting in economy of water use by the plant.

(iii) The effect of potash on the diffusive resistance of leaf stomata has been most pronounced in soils having moisture at 50 p.c. field capacity, which is comparable to very droughty situation.

At 50% F.C., the resistance significantly increase in the order $K_4 > K_3 = K_2 = K_1 > K_0$. At Field Capacity and 75% F.C. moisture levels, however, the resistance increases significantly only under 200 kg K_2O/ha application rate. The advantage of low level of potash application under droughty situation (50% F.C.) in increasing resistance to transpirational loss is marked, although high level of 200 kg K_2O/ha resulted in maximum water use economy by the plant at different moisture regimes.

(b) Leaf Water Potential

Leaf Water Potential (L.W.P.) was measured by isopiestic method. This method involves detecting density changes of the solution in which the plant tissue has been immersed due to uptake or loss of water by tissue. Before using the method, the leaf position and time of sampling were standardised. It has been observed that L.W.P. tends to decrease between 8 a.m. to 5 p.m.,

but there has not been any significant change in L.W.P. values with age from third to seventh leaves. In our study we have, therefore, used both third and fourth leaves at 5 p.m. Results so far obtained are presented in Tables 4.3 and 4.4 :

Table 4.3. *Effect of potash on the water potential of detached leaves (Average weekly data for three moisture levels expressed as '- ' bar)*

Week*	Levels of potash (K_2O, kg/ha)		
	0	100	200
1st Week	3.12	2.33	2.19
2nd ,,	3.30	2.51	2.31
3rd ,,	3.32	2.54	2.29
4th ,,	3.38	2.59	2.31

*after one month of potash application

The mean data of seven days in each week suggests that potash increases leaf water potential (L.W.P). However, the increasing effect of potash on L.W.P. is more pronounced in the case of plants grown in $\frac{1}{2}$ F.C. moisture level as shown in Table 4.4 :

Table 4.4. *Effect of potash on L.W.P. at various soil moisture status (mean of four weeks) expressed as '- ' bar)*

Moisture Regime	Levels of potash (K_2O, kg/ha)		
	0	100	200
F. C.	2.84	2.60	2.42
$\frac{3}{4}$ F. C.	3.28	2.54	2.28
$\frac{1}{2}$ F. C.	3.72	2.33	2.11

It is seen from above table that with increasing moisture stress L.W.P. decreases ('–'bar) in the absence of potash manuring, but the trend reverses with potash applications at rates 100 and 200 kg K_2O/ha. The effect of potash manuring in increasing L.W.P. has been found to be highest at rate 200 kg K_2O/ha, under 50 p.c. field capacity moisture status. From both diffusive resistance and leaf water potential measurements described above, it can now be said that higher dressings of potash (100–200 kg K_2O/ha) applied before the onset of drought may reduce the susceptibility of plants to drought.

Exhaustive cropping trial

The cumulative potash uptake : Time relationship shows two distinct mean rates of uptake during exhaustive cropping upto and after twenty weeks. The mean rates of uptake have been shown in Table 4.5 :

Table 4.5. *Mean rates of uptake of potassium by the grass under exhaustive cropping (data expressed as me K/100 g soil/4 weeks).*

	Source	Epoch I upto 20 weeks	Epoch II From 20-44 weeks
A.	**Long-term manurial experiments**		
B.43	K_0	0.0150	0.0030
	K_{45}	0.0362	0.0020
	K_{90}	0.0382	0.0020
	K_{112}	0.0428	0.0030
B.105	K_0	0.0332	0.0020
	K_{45}	0.0364	0.0020
	K_{90}	0.0400	0.0030
	K_{180}	0.0510	0.0020
B.	**Virgin Soils**		
	High K Status	0.102	0.004
	Medium K status	0.072	0.003
	Low K status	0.062	0.002

Although soils have not yet shown apparent s exhaustion, it is clear from the mean rates of that growth has been substantially impaired due t nuous withdrawal of potash from the native sou

Potash yields (dry matter × K concentration) the two epochs (I and II above) increase in the ing order :

A. Long term manured soils: $K_{180} > > K_{112} > > K_{45} > K_0$

B. Virgin soils : High potash status > M potash status > Low status.

Potassium acitivity ratio or K-intensity sho sharp decrease during the first nine weeks of cr irrespective of long-term manured and unma virgin soils, which may be due to rapid withdra potash by the grass at the begining of the cropping

However, from ninth week onwards the potas tensity values again started recovering and at t of 28th week attained the same levels as that of uncr soils (i.e. the initial values), which could be due release of non-exchangeable potassium to the pool. From 28th to 44th week potash intensity again tended to decline although not as fast as was ved during the initial cropping period. The K-int value of the cropped soils at the end of 44th wee of the order of $(40 \pm 3) \times 10^{-4}$ m.e./100 g soil, wl before cropping the K-intensity values ranged be 100-1600 m.e. K/100 g soil.

Cumulative potash uptake (m.e. K/100 g soil) 44th week of cropping has been found to be highly elated with K-intensity (immediately available) c cropped soils from all regions of N.E. India (r^2 - $P < 0.01$), as shown in Fig. 3. It may be noted th exhaustive cropping trial, 34 soils representing diff tea soils of N.E. India were taken.

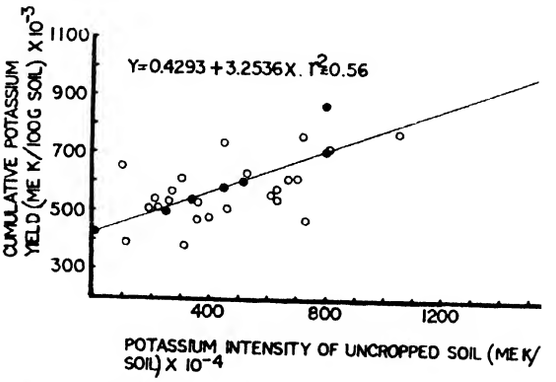


Fig 3. Relationship between cumulative potash u and K-intensity of uncropped soil.

Cumulative potash uptake (m.e. K/100 g soil) upto 44th week of cropping has also been found to be highly correlated with exchangeable potash content of uncropped soils from all regions ($r^2 = 0.62$, $P < 0.01$), as shown in Fig. 4. It can, therefore, be inferred that exchangeable potash content of the uncropped soils can be relied upon as a measure of "availability" for prediction of potassium uptake irrespective of the regional characteristics of the soils.

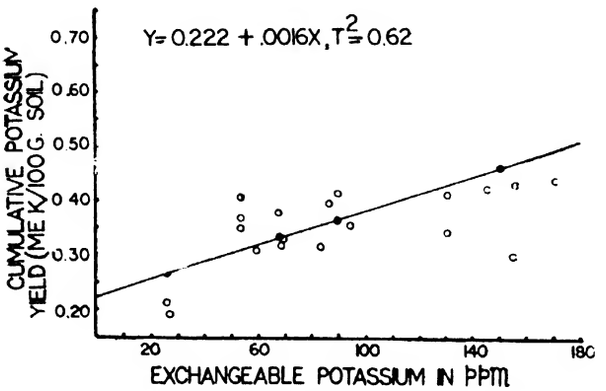


Fig 4. Relationship between cumulative potash uptake and exchangeable potash content of uncropped soil

Capacity-intensity relationship of soil potassium

It has been felt that to characterise the K-supplying power of soils, a suitable intensity measurement (I) coupled with information on how "I" values change on removing or adding known amounts of K to the soil (Q) may, in the light of our present knowledge, prove to be more useful than other conventional K-availability measurements. With this end in view Q/I relationships have been determined for the 34 different soils used in the exhaustive cropping trial. The Q/I relations or adsorption isotherms were determined covering a wide concentration range of potassium (0 to 10,000 micro molar KCl) at room temperature. It has been observed that "intensity" (I) of the soils examined is linearly correlated with the "capacity" (Q) and in most cases the straight line correlating I and Q passes through the origin indicating thereby that K is not tightly bound in our soil complex. These relations are true for all the soils studied so far. Gradients of the Q/I relations (tan θ) or, in other words, "potential buffering capacity" (P.B.C.) of the soils pool of labile potassium have also been calculated and shown in Table 4.6.

From the above table it is seen that P.B.C. does not vary appreciably between different regional soils, having a mean value of 2.0 ± 0.4. The narrow range of P.B.C. values suggest that tea soils, in general, have similar nature and extent of exchange surface indicating thereby similar pattern of release of native or applied potassium.

Table 4.6. *"Potential Buffer Capacity" (P.B.C.) of different soils.*

T.E.	Location	P.B.C. of soil
Samsing	Dooars	1.92
Rydak	,,	1.92
Teesta Valley	Darjeeling	2.22
Ging	,,	2.28
Cinnamara	South Bank	2.34
Haroocharai	,,	1.66
Naghreting	,,	2.43
Mankhoosi	,,	2.12
Loongsoong	,,	2.09
Cinnatolliah	North Bank	2.41
Derby	Cachar	1.85
Longai	,,	1.78
Hattikhira	,,	1.94
Isabheel	,,	1.91
	Mean	2.0 ± 0.4

As the P.B.C. values are of high order it is expected that tea soils will have better ability to maintain the concentration of potassium in soil solution at the root interface provided loss of K due to cropping is adequately compensated by K-manuring. Although adsorption isotherm studies will be extended further to include more soils belonging to different series and parent materials, it can now be safely said that the soil potassium release pattern is unlikely to be varying between different regions since the two unambiguous characteristics of soil potassium, viz, Q/I relationship and potential buffering capacity (P.B.C.) have been found to be almost the same for the different soils studied so far. This indicates that soil potash and crop correlation test should yield the same type of results both in Assam and West Bengal.

STUDIES ON ZINC IN RELATION TO TEA NUTRITION

Zinc has been proved to be an essential micro-nutrient for tea. Deficiency of zinc leads to malformations known as "little leaf" or "rosette" formation, sickle-shaped leaf and intravenal chlorosis. There are also evidences that zinc deficiency in tea can lead to significant decrease in yield. It is known for most crops that zinc content of plant tissues is much higher than the available content of Zn in their corresponding soils. Hence deficiency levels may set in soils especially under continuous cropping without zinc fertilisation. It has, therefore, been thought necessary to survey the available zinc status of North East Indian tea soils. For the purpose of surveying available zinc status of tea soils, the modified ammonium-acetate-dithiozone extraction method was used (details in Ann. Sci. Rept. 1975-76, P. 24). So far 337 top and sub-soils from different regions have been analysed for available zinc, the data for which are presented in Table 4.7.

Table 4.7 shows that most of the soils examined have a zinc content of between 3 and 27 p.p.m. and frequency wise about 64 p.c. of soils lie below 15.0 p.p.m. range and another 30 p.c. occur between 15 and 27 p.p.m. range. Further, a large percentage of old alluvium soils of Cachar and South Bank have higher zinc content as compared to the young alluvium of North Bank.

Table 4.7 *Distribution of available zinc in North East Indian tea soils*

Available Zn content in ppm	Soil Category	Percent of soils surveyed in South Bank	Cachar	North Bank	Dooars & Darjeeling	North I
< 3.0	1	6.80	2.00	2·95	0.87	
3.0 – 14.9	2	54.38	48.10	77·95	61.23	6
15.0 – 26.9	3	29.14	44.00	16·19	30.19	2
≥ 27.0	4	9.71	6.00	9·95	7.77	

The soils that fall in category 1 is rather very low, ranging roughly between 1 to 7 per cent in different regions. According to published results with respect to other soils, the range of available zinc between 1.5-3 p.p.m. has been considered as the boundary between zinc responsive and non-zinc responsive soils.

Profile distribution of available zinc down to 120 cm (at every 30 cm intervals) in about 40 profiles, as well as the differences between top (0-15 cm) and sub-soils (15-45 cm) of different locations have been found to be non-significant, thereby indicating a uniform pattern of distribution of available zinc in the effective root profile of mature tea.

In Darjeeling district soils for this project were collected aspect and elevation-wise, from North-East and South-West aspects and at elevations of 900 and 1800 meters respectively. Statistical analysis of available zinc data, however, did not show any significant influence of either aspect or elevation on the available zinc content of soils. However, from the point of view of regional distribution of Zn in Darjeeling there has been an indication that soils belonging to the Western parts are appreciably lower in available zinc content as compared to their counterparts in the Eastern part and Kurseong Mahanadi districts.

Zinc content of clonal leaf

The distribution of zinc in whole leaves, internodes and petioles of various ages has been examined with an aim to ascertain the extent of accumulation, if any, with the age of leaf and in different tissues. Results so far obtained are given in Table 4.8.

From the table it is seen that bud contains significantly higher quantities of zinc than the leaves from the first to the sixth position. The Zn content of any one of three clones does not differ appreciably. The Zn content of the leaf petiole is slightly lower than that of bud, but higher than that of the leaves. However, the zinc content of the internodes down to the sixth leaf is double that of the leaves in each one of three clones (mean Zn content of internode being 83 ppm against 42 ppm of the leaves). It can, therefore, be said that the internodes of tea leaves accumulate zinc to a large extent.

Table 4.8. *Distribution of Zinc in leaves of different age and in different tissues of three clones*

Leaf position	Ppm Zinc in clones TV_7	TV_{18}	TV
Bud	52.00	65.00	60.0
1st leaf	44.20	39.50	46.25
2nd leaf	43.20	43.50	43.75
3rd leaf	45.50	34.50	43.25
4th leaf	43.00	46.50	40.00
5th leaf	45.00	39.00	40.00
6th leaf	43.00	31.50	40.75
Mean of leaves	43.98	39.58	42.33
Leaf Fractions			
Petiole	48.00	54.00	54.25
*Internode 1	92.25	94.00	77.50
,, 2	83.75	94.00	62.50
,, 3	75.00	94.00	94.50
,, 4	64.50	74.00	78.50
,, 5	80.00	91.00	83.00
Mean of internodes	79.10	89.40	79.20

*Internode 1, i.e. Between 1st and 2nd leaf.
,, 2, i.e. ,, 2nd and 3rd ,,
,, 3, i.e. ,, 3rd and 4th ,,
,, 4, i.e. ,, 4th and 5th ,,
,, 5, i.e. ,, 5th and 6th ,,

Analysis has always shown the accumulation of amounts of phosphate by tea shoots even at low l of soil phosphorus, indicating luxury consumptio the element by the tea plant. This is a cond conducive to the accumulation of large amounts of in the form of zinc phosphate. It can, therefore inferred that insoluble zinc phosphate may lead to availability of these two elements, especially zinc. order to determine if insoluble P could lead to availability of the two elements particularly Zn, ex ments have been undertaken.

LEAF ANALYSIS

Diurnal changes in the Zn content of leaf

Different leaves (1st to 6th leaf) were analysed c few occasions for total zinc content throughout the from 6.30 a.m. to 4.30 p.m. during the plucking sea Mean Zn contents for three clones TV_7, TV_{18} TV_{20} are given in Table 4.9.

The variations in the zinc concentration of leaf (rage of 1st to 6th leaves) as well as fine (Two and a E and coarse (3rd to 6th leaves) components of tea sh with time are shown in Figs. 5 and 6 respectively.

From the table 4.9 it is seen that zinc content of ves from morning till afternoon, decreases although rate of decrease is pronounced in clones TV_7 and T than in TV_{20}. The pattern of these diurnal char

Table 4.9. *Diurnal changes in Zinc content of clonal leaves (data in p.p.m. Zn).*

Position of leaf	Zinc content in p. p.m.											
	TV_7				TV 18				TV20			
	6.30 am	9.30 am	1.30 pm	4.30 pm	6.30 am	9.30 am	1.30 pm	4.30 pm	6.30 am	9.30 am	1.30 pm	4.30 pm
Bud	75	48	46	26	101	62	62	35	70	62	60	48
1st leaf	63	44	43	27	70	48	28	12	51	49	45	40
2nd ,,	60	45	40	28	68	50	27	37	48	45	42	40
3rd ,,	60	50	45	27	68	40	20	10	53	45	40	35
4th ,,	56	41	47	28	88	44	40	14	46	46	36	38
5th ,,	65	47	48	20	84	44	10	7	46	41	38	35
6th ,,	60	40	46	26	74	42	12	10	53	40	35	35
Mean	63	45	45	26	79	47	28	18	52	47	42	39

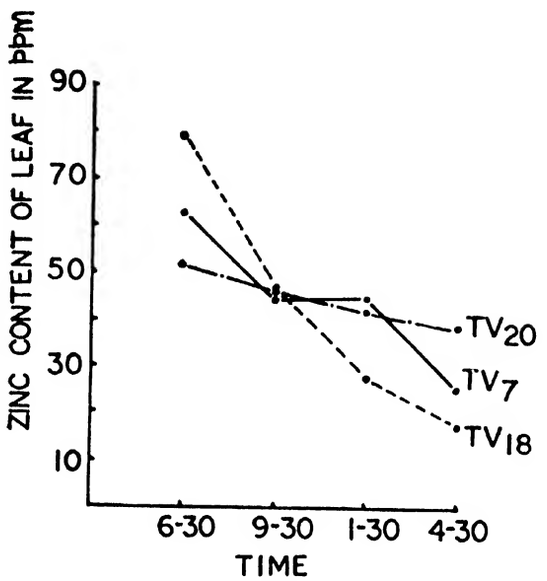


Fig 5. Durinal variation of leaf zinc content

9.30 and 1.30 p.m. On the contrary, in case of TV_{18}, a continuous sharp decrease is noted from 6.30 a.m. to 4.30 p.m., except in the bud. Diurnal changes of leaf zinc content in the case of TV_{20} have been found to be of a smaller order than in the other two clones. From the mean data of bud and all leaves it has been estimated that percentage decreases between 6.30 a.m. to 9.30 a.m. and between 6.30 a.m. to 4.30 p.m. are about 29 and 57 percents, respectively, for clone TV_7, about 40 and 75 percents, for clone TV_{18} and about 10 and 25 percents, for clone TV_{20}. As far as the clonal susceptibility to diurnal changes is concerned, it appears that Cambode (TV_{18}) clones are the most susceptible, followed by the Chinary (TV_7)clones, the Assam (TV_{20}) clones being the least susceptible. No change in the concentration of Zn has been observed in any of the internodes from morning till afternoon. Hence the observed decrease in Zn content of leaves of different ages from morning till afternoon cannot be attributed to translocation from leaf to internode, the Zn content of latter being always higher than in the leaf (c.f. Table 4.8).

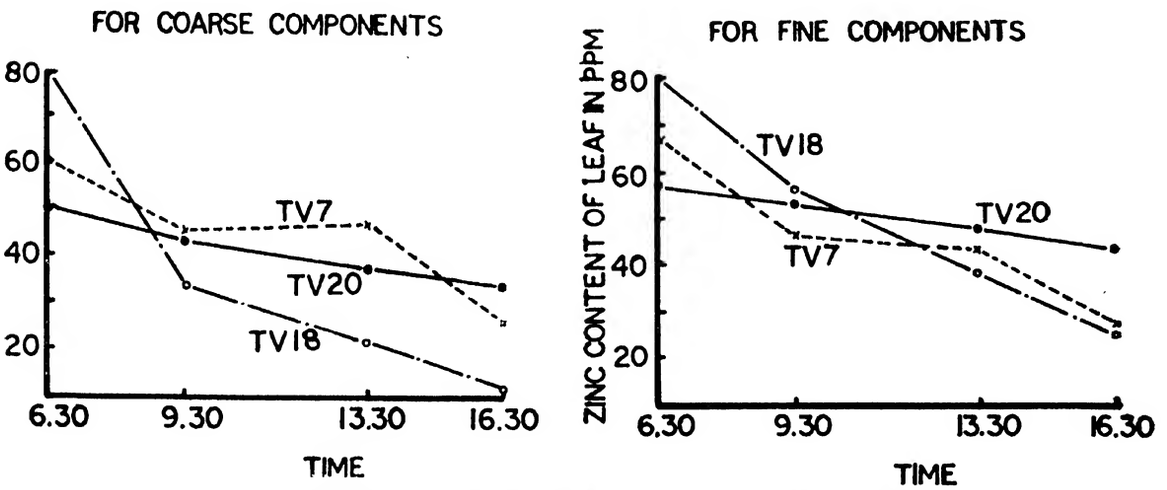


Fig 6. Diurnal variation of zinc content in fine and coarse components of tea shoot

in the different clones is, however, not the same. In the case of TV_7, two periods of sharp decrease have been noted namely between 6.30 and 9.30 a.m. and 1.30 and 4.30 p.m. and practically no decrease between

Cationic (Ca + Mg + K) and anionic (N+P) distribution in clonal tea leaf

The cationic and anionic balance in clonal tea leaves has been examined, utilising leaves of different ages

(first to sixth leaves) of four clones. Mean data of all the leaves are given in Table 4.10. In this exercise only the major cations and anions have been considered.

Table 4.10. *Cationic and anionic balance in clonal tea leaves (mean data expressed as percentage miliequivalent).*

Clone	Cations (K + Ca + Mg)	Anions (N + P)	Cations / Anions
TV_1	121	151	0.80
TV_7	108	114	0.95
TV_{18}	84	84	1.00
TV_{20}	102	83	1.23

It is seen from the above that there is almost a constancy in the cationic and anionic balance in the various clones studied so far (please see last column) observation based on the analysis of two and a h was reported last year (Ann. Sci. Rpt., 1975-7 The same trend has been exhibited this yea leaves of different physiological ages.

Nutrient Ratios of clonal leaves

Nutrient ratios, with special reference to major have been worked out with a view to find out ratios change between different leaf fractions a rent clones under standard agricultural practice are given in Table 4.11.

Table 4.11 *Nutrient ratios of shoots of four clones and their component parts (Mean of four observations)*

Nutrient Ratio	TV_1			TV_7			TV_{18}			TV_{20}	
	Fine	Coarse	Internode	Fine	Coarse	Internode	Fine	Coarse	Internode	Fine	Coarse
N/K	1.61	1.10	1.08	2.00	1.22	0.96	1.59	1.00	0.69	1.68	1.52
N/P	9.44	9.27	5.29	11.41	13.05	8.61	5.31	4.37	3.96	8.45	10.16
K/Mg	12.62	11.22	9.50	14.07	12.78	12.88	10.70	12.13	7.14	9.41	6.31
P/Zn				6.19	4.88	3.09	13.21	10.77	2.92	10.22	7.23

Fine component : Bud first and second leaf.
Coarse component : Third, fourth, fifth and sixth leaf.
Internode : All internodes between the first and the sixth leaf.

From the above table it can be seen that :

(i) N/K ratio decreases from fine component to internode irrespective of the clones;

(ii) N/P ratio does not significantly change between the fine and the coarse components, whereas the ratio generally decreases in the case of internode;

(iii) K/Mg ratio, in general, does not change much between the different components;

(iv) P/Zn ratio decreases in the internodes in all clones;

(v) The mean ratios of leaf fractions for N/K, N/P, K/Mg and P/Zn have been found to be 1.3 ± 0.20, 8.0 ± 3.0, 10.0 ± 2.0 and 7.0 ± 2.0 respectively. It will, be interesting to find out how these ratios will be affected by manuring and whether these ratios are better indices of uptake or response as compared to leaf nutrient concentrations.

Magnesium deficiency in clones and seed jats

Leaves of different clones and jats showing magnesium deficiency symptoms and their healthy counterparts have been analysed. From the information ga far the following tentative conclusions can be

(i) Both magnesium and the total cationic (C + K) contents of healthy leaves have bee to be higher than their Mg-deficient parts. Further K/Mg ratio of deficient a thy leaves practically remains unaltered contrary, Ca/Mg ratios of deficient lea relatively higher than those of the healthy

(ii) Leaf potash data do not seem to supp contention that magnesium deficiency induced by the cumulative effects of manuring, since comparison between d leaves, subjected to varying periods of manuring, do not show significant dif in magnesium content of the leaves.

As a matter of interest, the magn calcium and potassium contents of the d and healthy leaves as well as their rat shown in Table 4.12.

Table 4.12. *Mg, Ca, and K contents and their ratios in visibly Mg-deficient and healthy leaves of plants (data mean of two clones expressed as m.e. pe*

MOP applied @ 40 kg K_2O/ha	Conditions of leaf	Potassium K	Calcium Ca	Magnesium Mg	Total Cations K + Ca + Mg	K/Mg
For 1 year	Healthy	22.34	51.62	34.18	108.14	0.65
	Deficient	15.43	51.45	27.39	94.27	0.56
For 6 years	Healthy	27.66	50.66	30.91	109.13	0.89
	Deficient	22.88	46.98	26.64	96.50	0.86

STUDIES ON SOIL NITROGEN

Leaching loss and recovery of urea nitrogen

Leaching losses of urea nitrogen over six month period under simulated rainfall conditions in potted plants are shown in Table 4.13.

Table 4.13. *Leaching loss of nitrogen from urea*

Treatment		Net loss of nitrogen (mg N/pot)			PC of Urea nitrogen lost
Kg N/ha	Single or split applied	NH_4–N	NO_3–N	Total	
0		20.02	60.15	80.17	
60	* in 3 equal split	23.65	120.10	143.75	29.03
100	Single application	25.62	168.29	193.91	31.25
120	+ in 3 equal splits	24.76	180.45	205.21	28.55
200	Single application	30.45	189.01	219.46	29.13

* another 40 kg N remains to be applied in two equal splits.
+ another 80 kg N remains to be applied in two equal splits.

From the above table it is seen that about 30 percent of the nitrogen applied as urea is lost over a period of six months when potted plants were subjected to 160 cm (60 inches) of simulated rainfall. There had been practically no difference in the leaching loss of urea nitrogen either between the levels or between the methods of application. This confirms our earlier findings on sulphate of ammonia where it was found that leaching loss of nitrogen did not vary with levels of application, loss being about 40 p.c. over a period of twelve months at levels of 50, 100, 150 and 200 kg N/ha.

Nitrogen recovery values calculated so far (not shown here) indicate urea nitrogen efficiency varying between 30 to 50 percent depending upon applications at low and high doses respectively. This study is still in progress and the above should be considered as interim report.

LAND CLASSIFICATION

Land classification has been attempted for the first time in the tea areas of Nowgong, Golaghat, Jorhat, Nazira and Sonari circles. For this classification, twentyfive tea estates were selected following a grid pattern. The tea estates are located at 16 km intervals along the four well-marked contour lines in the topo-graphic map (Details in Tocklai Special Bulletin No. 9, 1977). In each tea estate, four soil profiles, representing North, South, East and West directions, were excavated for purpose of recording profile characteristics like texture, effective depth, permeability and slope in the field, and soil samples were collected to a depth of 120 cm at every 30 cm intervals for texture analysis in the laboratory.

Based on the results of detailed texture analysis a soil type map has been prepared for the aforesaid tea areas. From the soil type map, soil series have been identified namely, three in each of Nowgong, Golaghat and Sonari sub-districts, two in Jorhat sub-district and only one in Nazira sub-district. Major soil types are : silt loam to silty clay loam in Nowgong, loam to silty loam in Golaghat, loamy sand to sandy loam in Jorhat, silty clay loam in Nazira and loam to silty loam in Sonari.

From the field data and laboratory texture analysis lands in the five tea circles have been classified on a simplified system for their safe use and protection against erosion.

The classification shows that three classes of land, viz., classes III, IV, and V with few, moderate and severe limitations respectively occur in these tea areas. However, majority of the land belong to Class III, i.e., with few limitations from the point of view of erosion and conservation. The exceptions are the plateau lands and the low teelas of red bank soils. The rolling plateau lands on the extreme West of Nowgong centering round Kondoli T.E., from the West of Moabund T.E. upto Neghereting T.E., and from Tyroon T.E. to Borsillah T. E. to the South-West of Jorhat belong to Class IV and these lands are subjected to moderate erosion hazards. The low teelas of red bank soils, situated close to the Mikir Hills in Nowgong, separated from the Mikir hills by low lands in Golaghat and on the lower slopes of the Naga hills skirting Sonari, belong to class V and these lands suffer from severe limitations from the point of view of soil and water conservation. It has been suggested that intensive protection measures like contour drainage, contour planting, tie-ridging or ridge bunding and mulching should be adopted in soils of this class, especially in new plantations, for safe disposal of storm water and protection against erosion.

Land classification work was also carried out in a much more intensive fashion in one of the tea estates located in the plateau series of Dooars, where physical properties like surface hazard (presence of stone and pebbles), effective depth, permeability, slope, wetness and texture were measured either during the field trials trips or in the laboratory. One hundred and twelve profiles were excavated in a close grid for collection of field data and soils from these profiles were also used for laboratory analyses for physico-chemical properties. It has been found that most part of this tea estate belong to classes III and IV with few and moderate erosion hazards, respectively. The main limitations have been identified to be moderately shallow to shallow soils, low moisture retention capacity, slightly stony soil (about 60 p.c. stones and pebbles of size diameter greater than 2 mm) and high permeability. To overcome these limitations, it has been suggested that water conservation measures may be adopted on a micro catchment level, i.e., on a single plant level (tie-ridging, strip mulching etc) as practised in Central African tea areas, besides providing contour drains and bunds and planting tea on the contour.

STUDIES ON GROUNDWATER DRAINAGE PROBLEMS

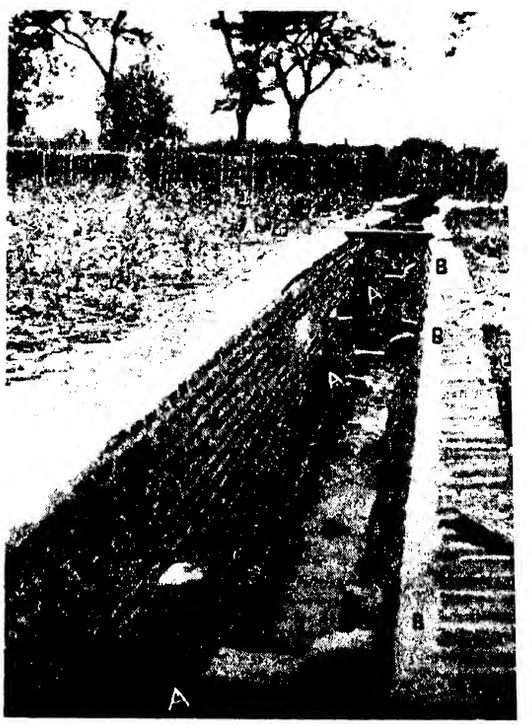
Work on diagnosis and solutions to sub-soil drainage problems (specially problem of high groundwater tables)

has been initiated under United Nations Development Programme. The objectives for diagnostic work are as follows :

(i) Obtain quantitative information regarding water tables actually prevailing throughout the monsoon period in as many estates as possible;
(ii) verify if impeding layers in the soil profile, causing "perched water tables", are of importance;
(iii) ascertain which part of the rainfall in monsoon discharge as surface run-off; and
(iv) establish criteria for ground water table control.

For fulfilling the above objectives, piezometers have been installed in thirteen project sites laid out under direct control of the department, in three "pilot estates" namely, Tocklai (the station's own estate), Hunwal and Haroocharai. These sites are so chosen as to show different degrees of apparent water-logging symptoms. Besides daily observations of water table in the piezometers, water levels in open drains and recipient hulas or streams adjacent to the sites are also being recorded throughout the monsoon. Preparations have also been made for installation of piezometers in another thirteen sites distributed in tea estates around Jorhat and Golaghat, where observations will be made by the estate staff under guidance of Tocklai. In each of the above sites, on an average 35-40 piezometers have been installed, the principle being to install one or two rows of piezometers perpendicular to the main or sub-main drains and similarly another one or two rows of piezometers mid-way between two secondary drains and parallel to them.

Simultaneously with the diagnostic work, pipe drainage experiments have been laid out on a small scale in three project sites at Tocklai and Haroocharai tea estate to control groundwater table, where 60-70 m asbestos cement pipes in a gravel envelope have been laid out at a depth of about 1.5 m and at a spacing of 13 m. The set up of pipe drains in the "pilot estates" has been kept to the minimum but the arrangement permits testing the performance of drain lines in replicates. All the pipe drains flowing into the collector ditch have been provided with long end-pipes to enable measurement of the outflow from the drain lines (as shown in the photograph). Drain flows and groundwater levels are being daily recorded in the pipe drainage experimental sites during well spread out drainage events "lasting" for 3-7 days after heavy or medium intensity rainfall. The recession of the water table from a point in the upper 50 cm of soil at the mid-point between drains down nearly to the drain depth has been termed as "drainage event". The recommended technique of mannual measurement using a container of known volume and stop watch has been followed for measurement of outflows from the pipe drains. A complete evaluation of the performance of pipe drains is only possible at the end of the current drainage season,



PIPE DRAINAGE SET UP
(Tocklai Demonstration Plot)

A : Cement asbestos pipe 7.5 cm. diameter, placed at a depth of approximately 150 cm., spacing 12 m × 12 m.	**For disposal of s soil water and cont of ground water tal**
B : Cement asbestos pipe, 15 c.m. diameter, placed at the mouth of open shallow surface drains (30 cm. top diameter, 15 cm. deep), spacing 36 m × 36 m.	**For disposal of s face-run of.**

although both water table and flow data are anal after each drainage event. The performance para ters (for testing the drain lines) namely entrance r ance r_e and the ratio 'he/h *tot*' (entrance head loss total head loss) so far calculated suggest good pe mance of the test drain lines, r_e and he/h *tot* being than 0. 75 and 0.2 respectively. In addition a pum experiment has been initiated for improvement of drainage of an area of 42 ha under tea in Harooch T.E. In this estate satisfactory gravity drainage can always be effected owing to lack of sufficient out The aim of the experiment is to find out whether pu ed drainage will help during *critical* monsoon per in lowering the ground water table and thereby imp ving growth and yield of tea.

Two 14 H.P. Kirloskar Diesel Pumps have b installed at the outlet point. These pumps have charge capacity of 68 litres per second, with an eng speed of 1,500 r.p.m. and a total head of 8 metres.

pump drainage system should be able to cope with a rainfall of 30 mm/day or a discharge of 5.5. c.ft. per second when both pumps are working simultaneously. All drainage water from 42 ha tea area is diverted to a 600 metre long channel (top diameter 4.5 m) with a drop of only 0·3 m in 600 metre which has been bunded (2.7 m height) at the outlet for pumping out drainage water across the bund. Design water level (i.e., water level at design discharge) in the channel has been taken to be about 0.55 m. Pumps will only work when the design water level is exceeded during critical monsoon periods, otherwise drainage water will be taken out by gravity by opening the sluice gate provided on the bund at the outlet end. Piezometers have been installed, following the same layout as described earlier, for monitoring the groundwater table throughout monsoon in both pump drained area (42 ha) and control area (about 50 ha) where existing drainage system of the estate has been kept unaltered.

Besides water level measurement in the piezometers, water levels in the channel, collector drains and hula (adjacent to the groundwater observation plots)are also recorded. Arrangement has been made to record discharge of pump at given lift and given engine speed as well as time of pumping for working out pump efficiency.

RESEARCH AND ADVISORY SOIL ANALYSIS

A total of 66,000 soil tests were carried out during the year. The break up is as follows :

Research : 3,500 estimations.

Advisory : (a) **Tocklai Unit** (This excludes departmental project analyses).
48,000 estimations.

(b) **Dooars Unit :**
15,000 estimations.

Plant Improvement

1. Trial of Biclonal seed stocks

The long-term trial of five biclonal stocks at Tocklai planted in 1973 (Ann. Rep. 1973-74, p. 42), produced sufficient leaf during the year for manufacture in 1 kg rollers. From the yield trend and quality tasting in comparison to Tocklai Biclonal Stock 449, three of the stocks are found to be promising. The trial will be continued for a few more years for observing yield trend and quality before final assessment.

Trial of the same stocks are also in progress in the Dooars and Cachar for observation of their drought resistant properties (Ann. Rep. 1974-75, p. 32). The young seedlings of all the five stocks have thrived well in the prolonged dry period of 1975, and initial yield results are quite encouraging.

Seeds from these stocks have also been distributed in different regions of Assam, Cachar and the Dooars for establishing observation plots.

2. Micro-seed baris

On the basis of pollination results and short term trial of the hybrid seeds, altogether eighteen biclonal combinations were found to be promising and were selected for establishing micro-seed baris for production of seed under natural conditions. Three micro-seed baris of biclonal combination selected earlier will be planted out in 1977.

3. Cytological investigations

Detailed cytological investigations were carried out on the triploids, tetraploids and aneuploids derived from a natural triploid plant (Ann. Rep. 1969-70, p. 40). The progenies showed extreme variations in their chromosome number ranging from diploid (2n = 30) to pentaploid level (2n = 75). While most of the polyploids and aneuploids were generally vigorous, the pentaploid plant was extremely slow growing and stunted in character and did not survive inspite of all the care. Out of the 14 plants surviving, one plant was found to be diploid (2n = 30) and three were tetraploids (2n=60). The rest of the plants were aneuploids in character, showing chromosome numbers around diploid (2n = 32 and 33), triploid (2n = 38 and 42) and tetraploid (2n = 58, 59, 61 and 63) levels. Two of the plants with average chromosome number 2n 60 appeared to be aneusomatic in character, often certain cells in the same tissue bearing chromosome numbers above or below the normal.

The aneuploids and polyploids vary considerably in their morphological characters and are found to be fertile. Further investigations are in progress to determine the possibility of identifying individual chromosomes associated with specific characters, so as to use them in future breeding schemes.

4. Selection of vegetative clones

Thirtyfive bushes were selected from hybrid p resulting from artificial crosses. The bushes put to long term trial as soon as sufficient cutt come available.

Rooting trial was completed for the 22 mothe selected from neighbouring estates (Ann. Rep. p. 28), out of which only six clones were foun good rooters. On the basis of nursery vigour, t essful clones will be planted out in long-term tria autumn 1977.

5. Long-term trial of clones

One more long-term trial was planted with 16

A total of about 112 clones are at present in stages of long-term trial. Three of the long-ter completed five years in the field, out of which fou were found promising. These clones will be for a few more years before making final selecti

From another long-term trial which complet phase of one pruning cycle, three clones were f be outstanding in cup-characters and yield.

6. Selection of clones in tea estates

The survey of tea germplasm and clonal selectio was continued in different regions of N.E. Indi tates where selection work was carried out earlie also helped in every step in conducting the trials area surveyed during the year and the number of selected are as follows :

Region	No. of Estates	Area surveyed in hect.
Assam South Bank	7	317.55
Assam North Bank	10	751.99
Terai	5	457.66
Dooars	12	695.92
Cachar	5	316.71
Total :	39	2539.83

Plant Physiology

1. Selection of drought resistant clones

To isolate the factors responsible for drought res of clones, some of the anatomical and morphc characteristics of leaves of different clones were s The object of the study was to find out if some of these features could be utilized for the selec drought resistant clones.

The drought resistance or drought susceptib most of the Tocklai released clones has been ide from their performance during prolonged dry p in regions like the Dooars and Cachar. On th of their performance, clones have been cate into good, fair and poor drought tolerant groups. clones, from each of the good and the poor d

tolerant groups, were taken for the study. The clones TV 7 and TV 11 are from the drought tolerant and TV 2 and TV 3 from the drought susceptible group. The observations were carried out on such anatomical features of the leaf as (a) Cuticle thickness, (b) Area of intercellular space, (c) Palisade thickness, (d) Size of mesophyll cells and (e) Leaf blade thickness.

The data obtained so far show that the drought tolerant and drought susceptible clones differ significantly in cuticle thickness and the area of intercellular space. Both the clones of the drought tolerant group possessed thicker cuticle but less intercellular space in comparison to the clones of the drought susceptible group. These two anatomical features may prove useful in the identification of drought susceptibility of clones. The other features did not show any difference between the clones of the two groups. Further investigations are in progress.

2. Dry matter content

In continuation of the previous investigation on diurnal and seasonal variation in percent dry weight of plucked shoots and their components (Ann. Rep. 1975-76, pp. 30-31), further observations were made on the effect of plucking at 9 A.M. and 1 P.M. on the dry matter content of tea shoots. Results are presented in Table 5.1.

Table 5.1. *Dry weight of shoots of various clones plucked at 9 a.m. and 1 p.m. during the season*

Month	Plucking rounds	% dry wt. 9 A.M.	% dry wt. 1 P.M.	Percent increase
		TV 3		
June	3	20.6	21.8	5.8
July	4	21.4	22.6	5.6
August	4	21.1	22.1	4.7
September	3	20.0	22.8	14.0
October	4	19.9	21.5	8.0
November	4	18.8	21.4	13.8
Average		20.3	22.0	8.6
		TV 9		
June	3	19.7	20.9	6.1
July	4	20.0	21.5	7.5
August	4	20.2	21.1	4.5
September	3	19.4	19.5	0.5
October	4	18.8	20.3	8.0
November	4	18.5	20.2	9.2
Average		19.4	20.6	6.0
		TV 11		
June	3	20.2	21.6	6.9
July	4	21.0	22.2	5.7
August	4	21.0	21.9	4.3
September	3	19.9	21.6	8.5
October	4	18.1	19.8	9.4
November	4	18.5	20.2	9.2
Average		19.8	21.2	7.3
		TV 16		
June	3	19.3	20.5	6.2
July	4	19.6	20.1	2.6
August	4	19.9	20.8	4.5
September	3	18.5	20.5	10.8
October	4	19.6	19.5	– 0.5
November	4	17.7	19.3	9.0
Average		19.1	20.1	5.4
Overall Mean		19.7	21.0	6.8

It can be seen from the table that the percent dry weight of shoots plucked at 1 P.M. is higher than that of shoots plucked at 9 A.M. in all the four clones throughout the season. There was only one exception during October when the dry weight of clone 16 slightly decreased at 1. P.M.

The mean increase over the year in dry weight at 1 P.M. over 9 A.M. varies from 5.4 to 8.7 percent between clones. There are variations in dry weight content between and within clones in different months of the year. In spite of these variations, all the four clones registered considerable increase in dry weight for pluckings at 1 P.M. over 9 A.M., the mean increase for the four clones taken together being 6.8 percent. This means that the recovery of made tea from the same quantity of green leaf will be higher by more than 5 percent if leaf is plucked at 1 P.M. instead of at 9 A.M. Increament of the dry weights of first and second leaves between 7 A.M. and 11 A.M. was reported in Ann. Rep. 1975-76, pp. 30-31, which corroborates with the present finding.

Dry matter content of shoots averaged for 9 A.M. and 1 P.M. Plucking is shown in Table 5.2.

Table 5.2. *Dry weight of clonal shoots averaged for morning and noon plucking*

Clones / Month	TV 3	TV 9	TV 11	TV16	Average
June	21.2	20.3	20.9	19.9	20.6
July	22.0	20.7	21.6	19.8	21.0
August	21.6	20.6	21.4	20.3	21.0
September	21.4	19.4	20.7	19.5	20.2
October	20.7	19.5	18.9	19.5	19.6
November	20.1	19.3	19.3	18.5	19.3
Average	21.2	20.0	20.5	19.6	20.3

Dry weight content of clonal shoots was higher during July-August and lower during October-November. High yielding clones in general has a lower dry matter content in their shoots. The seasonal trend of dry matter of different clones is shown graphically in Fig. 5.1.

The percent contribution of the different shoot components towards total dry weight of only the growing shoots of all the four clones plucked at 9 A.M. and 1 P.M. was estimated on 22 occasions from June to November. For the sake of brevity yearly mean figures only are given in Table 5.3.

It can be seen from Table 5.3 that plucking at different hours of the day (9 A.M. and 1 P.M.) has not effected any change in the relative contribution made by the different components of a shoot towards its total weight, although the proportion of bud, first leaf etc. varies from clone to clone. Furthermore, the proportion of the components constituting a growing shoot did not change at different times of the year in any of the four clones. This is illustrated in Fig. 5.2 with data from one of the clones, TV 16. Thus the proportion of the finer and coarser components of the growing shoot was not altered by plucking at different hours of the day or at times of the year.

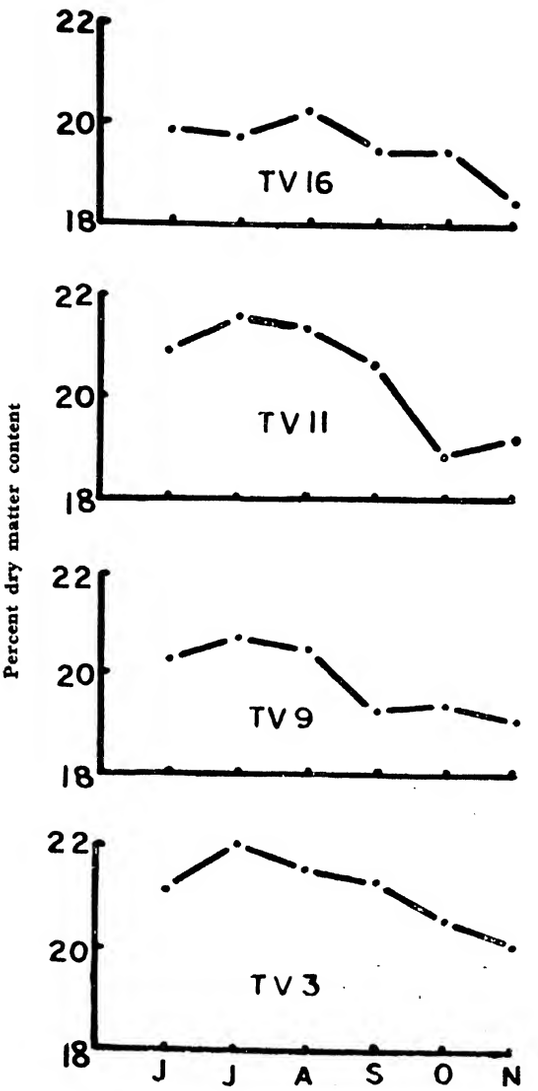


Fig. 5.1. Dry matter content of plucked shoots during the season

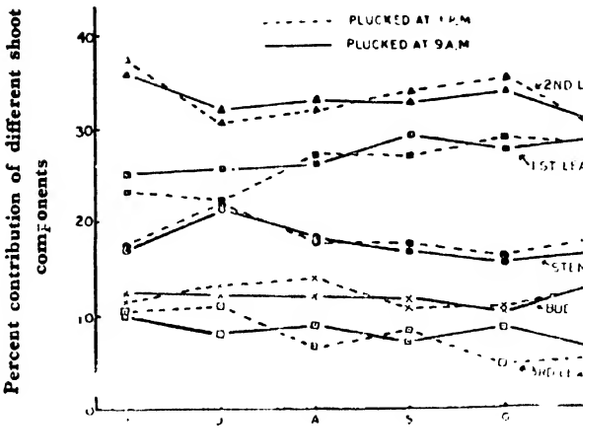


Fig. 5.2. Mean proportion of the components constitu a growing shoot of TV 16 during the season

However, varying quantities of banjhi shoots a also plucked from all bushes at different times of the ye The banjhi shoots have small buds and the proporti of other components also differ from that of the growi shoots. Hence the proportions of shoot compone given in Table 5.3 would have been different if bo growing and banjhi shoots were included in the measu ments instead of taking growing shoots alone. T total dry weight of banjhi shoots harvested at eve plucking round was, however, estimated for each of t four clones and shown in Table 5.4 as percentage of t total dry weight of shoots harvested at different mon of the year.

Table 5.4 shows that the percent contribution banjhi shoots towards total dry weight of crop var between clones and also at different months of the ye The variation is less pronounced between clones th between different times of plucking. There has be a progressive increase in the proportion of banjhi sho as the season advanced and this finding is in agreeme with our previous results (Ann. Rep. 1957, p. 72), w

Table 5.3. *Contribution of the components towards total dry weight of plucked shoots*

Clone	Time of plucking	Shoot components					
		Bud	1st leaf	2nd leaf	3rd leaf	Stem between	
						Bud and 2nd leaf	2nd leaf & 3rd leaf
TV 3	9 A. M.	15.48	31.31	32.96	6.11	8.22	5.92
	1 P. M.	15.94	28.89	32.00	7.59	8.33	7.23
TV 9	9 A. M.	12.94	24.65	32.87	8.48	9.63	11.48
	1 P. M.	12.86	25.60	31.47	8.64	10.00	11.42
TV 11	9 A. M.	15.44	30.67	34.49	6.94	7.00	5.45
	1 P. M.	15.41	30.84	33.70	8.18	6.83	5.65
TV 16	9 A. M.	12.85	28.60	32.73	8.11	9.11	8.60
	1 P. M.	13.49	28.28	32.97	6.88	9.74	8.69
Mean	9 A. M.	14.18	28.81	33.26	7.41	8.49	7.86
	1 P. M.	14.42	28.40	32.53	7.82	8.72	8.25

Table 5.4. *Dry weight of banjhi shoots expressed as percentage of the total dry weight of shoots plucked in Unpruned tea*

Month	Clones				Mean
	TV 3	TV 9	TV 11	TV 16	
June	35.70	22.92	16.44	21.96	24.71
July	9.33	9.66	13.10	11.90	11.00
August	14.50	10.40	16.64	15.10	14.16
September	16.71	12.17	12.69	26.38	16.99
October	33.74	27.36	27.89	44.70	33.42
November	34.08	43.98	23.19	34.43	33.92
Mean	24.31	21.08	18.33	25.75	22.37

the only difference that the proportion of banjhi shoots has been high in the present investigation in comparison with the earlier one. This difference may be attributed to the fact that the previous study was made on annually pruned bushes, while unpruned bushes were taken for the present investigation. The high percentage of banjhi shoots found in June in all the clones suggests that unpruned bushes go through a banjhi period at this time of the year.

The annual contribution of banjhi shoots towards total crop varied between clones from 18.3 to 25.8 percent with an overall mean of 22.4 percent, which is about twice as much as of annually pruned tea. Percentage of banjhi shoots is much higher in October-November in all the clones. The lower percentage of banjhi shoots in clone TV 11 is striking, but it cannot be explained in terms of the length of growing and banjhi periods.

3. Investigations on bud dormancy in tea

Certain plant growth regulators like gibberellic acid are known to induce early bud break while growth retardants like CCC suppress growth at higher concentrations initially, which is compensated at a later stage by enhanced growth. However, at lower concentrations even some growth retardants like CCC have been observed to behave like growth promoters. Against this background, two experiments were initiated, one to study the efficacy of different growth regulators in inducing early budbreak and the other to study their effect on crop distribution.

To study the effect of growth regulators on early bud break, six growth regulators (4-CPA, GA_3, BA, CEPA, SADH and CCC) were tried out on deep skiffed bushes of clone TV 9. Aqueous solutions of the growth regulators were sprayed on the bushes on four different occasions, i.e. on 4, 11, 18 and 25 February 1977. The number of buds sprouted by the third week of March was counted and subjected to statistical analysis. No growth regulator treatment was found to enhance early bud break significantly although some of the treatments with growth regulators appear to have increased the number of buds per unit area of bush surface. Time of application also seemed to be important.

Treatments GA at 100 ppm and 500 ppm, CCC at 100 ppm and SADH at 100 ppm and 500 ppm produced more primaries per unit area of bush surface than the control. The number of shoots plucked are being recorded and the final assessment of the treatment effects will be made by the end of the year. It is proposed to continue the experiment for a couple of years more.

4. Crop Distribution

The effect of the growth regulators (except 4-CPA) on crop distribution was studied on unpruned bushes of the three clones 16.12.15, 16.10.8 and 16.8.7. The chemicals at three concentrations were sprayed on the bushes on 9th March 1976. Plucking was done at weekly intervals and the plucked shoots from each clone were manufactured on 25 occasions by the C.T.C. method. The teas were evaluated by the Tocklai Taster. The growth regulators were again sprayed on one repeat in September and on another repeat of the trial in November to see if the latter treatments would extend the plucking season.

It appears that GA_3 increases early crop while the growth retardants CCC, SADH and CEPA suppress early crop and produce more during the later part of the year, compensating the early suppression. Repetition of hormone spray in September and November did not prolong the plucking season, and all bushes became banjhi by December.

The clones varied in yield in response to the treatments of growth regulators, particularly to the later treatments. No definite conclusion is possible at this stage regarding the effect of the chemicals on the quality of made teas.

Based on these observations, a full scale trial has been started during the year using clones TV 7, TV 15 and TV 18 representing Chinery, Assam and Cambod types of tea respectively and the growth regulators GA_3, CCC, SADH and CEPA.

5. Photosynthesis and translocation studies using C^{11} isotope

An experiment was initiated using C^{14} isotope to study the photosynthetic CO_2 fixation and translocation of labelled photosynthates in tea bushes. Five one-year old plants from each TV 1, TV 18 and TV 20 (Fig. 5.3a) and a mature bush of a seed jat in pots were used. Individual plants were exposed during December 1976, to 100 μc of $CO_2{}^{14}$ in open sunlight so that light does not become a limiting factor (Fig. 5.3b). Individual single stemmer potted plants were enclosed in transparent polyethene bags and the bottom of the bag was tied around the main stem. Radioactive $CO_2{}^{14}$ was injected from the top of the enclosure. Plants intended for photosynthetic $CO_2{}^{14}$ fixation studies were exposed for 2 hours, whereas the plants meant for translocation studies were exposed to $CO_2{}^{14}$ for 24 hours to get the maximum CO_2 utilised by the plants. The plants were uprooted after different intervals and processed for radioautographs made by exposing X-ray films to

Fig. 5.3a. Potted one-year old TV 1, TV 18 and TV 20 plants before Co_2^{14} exposure

the mounted plant specimen treated with CO_2^{14}. The plant tissue containing C^{14} isotope produces the dark shadows in the X-ray film.

Radioautographs of one plant in each clone and mature seed jat, harvested immediately after 2 hours of exposure, were examined for the CO_2^{14} fixation. Figure 5.4a shows that the label distribution in the leaves was uniform and as such no discernible difference could be found. As the plants were in banjhi state, the leaves were all mature and hence no difference in CO_2^{14} fixation could be observed. In case of the mature seed jat, the leaves at upper canopy appear to have fixed more CO_2 than the leaves in lower layers (Fig. 5.4b). Light might be the limiting factor for the lower leaves.

One set of plants in each clone was harvested in the month of February 1977, about 45 days after CO_2^{14} exposure (24 hrs) and the radioautographs were examined for C^{14} label distribution. Besides the leaves, the roots were also found labelled at this time with the rootlets and root-hairs showing more intensity (Fig. 5.4c). The meristematic regions such as rootlets, growing axillary buds and apices could be identified as the sink in a tea bush.

Another set of plants was harvested during March 1977, when the plants had produced spring flushes and the radioautographs were examined. The new flushes were less intensely labelled than either old leaves or roots (Fig. 5.4d). The new flushes near the C^{14} treated leaves were more intensely labelled than the flushes located farther from the old leaves. Possibly the old leaves and stem contribute towards the early spring

Fig. 5.3b. The plants being exposed to Co_2^{14}

flushes, rather than the roots. The observation radioautographs will be quantified by subjecting tissue samples for counting in GM Counters. Fur observations are continued.

6. Use of growth retardants on tea bush to p mote rooting of cuttings

An observational trial was taken up to investi the possibility of improving the rooting capacity of p rooting clones like TV 13 by foliar application of d rent growth regulators on the mother bushes, especi the growth retardants. Application of growth re dants to the mother bush before taking cuttings expected to restrict shoot elongation and enhance starch accumulation in the stem, which in turn m aid the rooting of cuttings. Five retardants (C CEPA, SADH, MH and Morphactin IT-3456) and promoter (IBA) in four concentrations were spra on TV 13 mother bushes one month prior to tal cuttings. Some of the treatments showed prom Further investigations are continued.

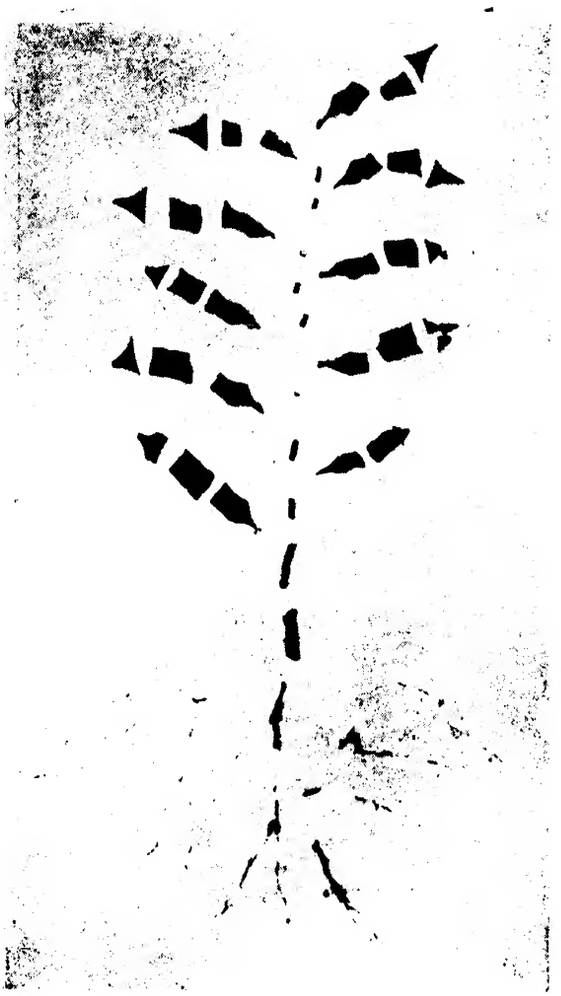


Figure 5.4a. Mounted Specimen

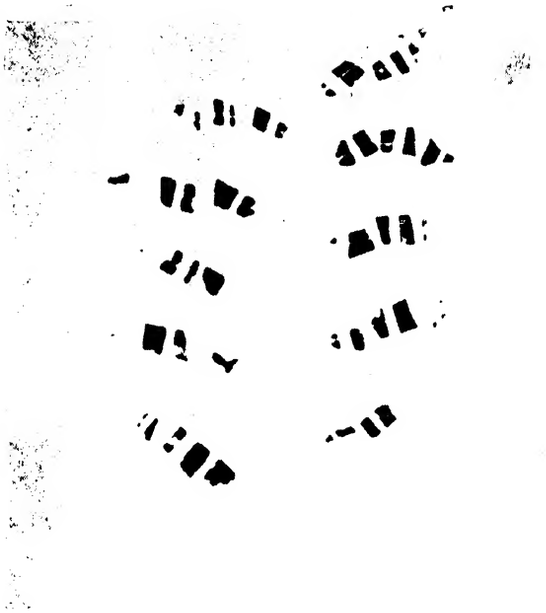


Figure 5 4a. Radioautograph
(No activity in the root zone)

Figure 5.4b. Mounted specimen

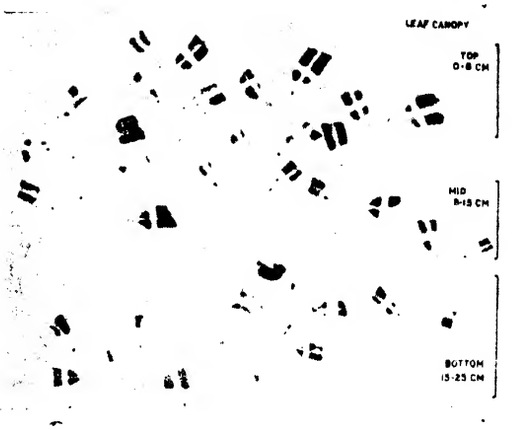


Figure 5.4b. Radioautograph (Note the difference in intensity in layers of canopy.
TL = Top layer, ML = Middle layer,
BL = Bottom layer)

Figure 5.4c. Mounted specimen

Figure 5 4c. Radioautograph
(See the activity in roots).

Figure 5.4d. Mounted specimen

Figure 5.4d. Radioautograph (Note the difference of intensity between roots (R), old treated leaves (OL) and the new flushes (NF).

Shot hole borer has been reported for the first time : attack of this pest is restricted to old tea in some areas of upper Assam. Red spider attack is more on clones with erect leaves. Scarlet mite prefers 4th and 5th leaf for oviposition and during cold weather its population is highest in lower zone of young and mature tea leaf canopy. Mite populations may increase with application of zinc sulphate. Biology of three new scales have been worked out. Nematodes may cause damage even at low level of abundance. Eight commercial formulations of acaricides and six insecticides have been evaluated against pest complex of tea. Acaricidal spray may increase crop to about 22%.

Biology of mites

Clonal susceptibility of mites : Susceptibility of Tocklai clones TV11, TV12, TV13, TV14 and TV15 to scarlet mite, *Brevipalpus phoenicis* (Geijskes), was assessed from its fecundity on these clones maintained at 19°C with 70% R.H. Egg laying was high on clones TV13 and TV14 than on clones TV11 and TV12. The trend in egg laying is similar to that obtained at controlled temperature of 32°C and 75% R.H. (reported last year), though at 19°C lesser eggs were laid.

Life-cycle of scarlet mite was studied at 23°C and 28°C on clones TV1, TV2, TV3, TV4 and TV5. At 23°C the life-cycle was completed in about 32 days and at 28°C in about 26 days on all the clones. The higher the temperature the lower was the duration of the life cycle and this was well reflected in the mite population build up under field conditions.

Fecundity of the scarlet mite on 1st, 2nd, 3rd, 4th and 5th leaves of a shoot was studied. Results (Table 6.1) show that on all the clones more eggs were laid on 5th leaf and minimum eggs were laid on 1st leaf.

Table 6.1. *Fecundity of scarlet mite on different leaves of different ages*

Average number of eggs laid: oviposition period (in parenthesis)

Clones	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf
TV 1	13.85 (18.09)	12.00 (19.70)	13.00 (17.30)	14.85 (18.30)	16.00 (18.30)
TV 2	6.20 (14.30)	6.50 (14.00)	7.70 (15.70)	7.85 (15.30)	8.65 (17.30)
TV 3	10.20 (20.00)	11.65 (21.70)	13.00 (22.30)	15.15 (21.00)	16.85 (22.30)
TV 4	5.30 (15.00)	6.50 (16.00)	8.00 (15.70)	8.80 (17.00)	8.65 (17.30)
TV 5	10.70 (20.30)	11.80 (19.00)	15.00 (20.30)	15.85 (20.70)	17.00 (19.70)

Fecundity and duration of life-cycle of red spider : *Oligonychus coffeae* (Nietner) **in relation to leaf age and leaf postures:** Three clones were selected to represent different leaf postures : TV1 for erect, TV3 for horizontal, and TV20 for droopy leaves. One shoot with 5 leaves from the top represents one replication and there were five replications for each clone : the number of leaves for each clone was therefore 25. To study fecundity one freshly emerged adult female red spider was introduced to each leaf.

Table 6.2. *Mean oviposition period of red spider on leaves of different ages of different types of clones*

Clones	Mean oviposition period in days				
	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf
TV 1	7.40	6.40	9.40	10.00	9.80
TV 3	6.40	6.00	7.20	8.60	8.20
TV 20	6.60	6.00	7.40	8.80	8.40

Results (Fig. 6.1) show that maximum eggs were laid on clones with erect leaves (TV1), followed by both horizontal (TV3) and droopy leaf (TV20). In all cases more eggs were laid on 3rd, 4th and 5th leaves and oviposition period was slightly longer on 4th and 5th leaves than on other leaves (Table 6.2). The difference

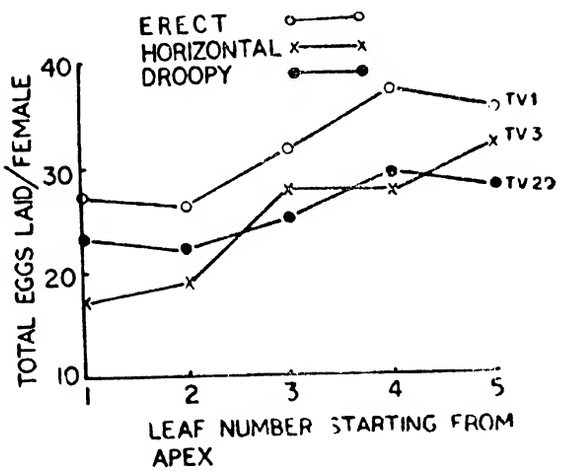


Fig. 6.1. Fecundity of red spider on leaves of different ages

in oviposition period and total eggs laid by red spider on these clones may be due to a combined physical effect of variability in leaf posture and their matty surfaces. No difference was noticed in the duration of developmental stages in the leaves of different posture, the average incubation period was five days and duration from hatching to emergence of adult was 8 days. These are based on observations on 33-40 individuals.

Distribution, abundance and succession of mites in relation to field management practices

Red spider population in relation to longer pruning cycle : Incidence of red spider was assessed during March 1976 to January 1977 from 100 randomly selected leaves on tea under different pruning i.e. medium skiffed, unpruned,

deep skiffed and top pruned. The degree of infestation was in the order unpruned > medium skiffed > deep skiffed > top pruned; the overall population of red spider per leaf being 6.40, 5.45, 2.49 and 0.18 respectively. This shows the intensity of attack varied directly with the amount of foliage left on bushes after pruning, though other factors may also be responsible.

Susceptibility of Tocklai clones to red spider: At Borbhetta assessment of red spider population on clones TV1 to TV19 during April to November was made by sampling 225 leaves each month from each clone. During this period TV1 (0.32 mite/leaf), TV3 (0.23 mite/leaf) and TV7 (0.27 mite/leaf) had more population than clones TV16, TV17 and TV19 (0.11/leaf in all cases). Rest of the clones occupied an intermediate position (Table 6.3). The reasons for this variability are not clear though leaf characteristics might be a contributory factor.

Table 6.3. *Overall population of red spider on Tocklai clones during April to November 1976*

Clone TV	Average number of red spider per leaf
1	0.32
2	0.17
3	0.23
4	0.16
5	0.17
6	0.14
7	0.27
8	0.16
9	0.16
10	0.18
11	0.15
12	0.13
13	0.14
14	0.12
15	0.13
16	0.11
17	0.11
18	0.18
19	0.11

Susceptibility of experimental clones (type) to red spider: Incidence of red spid the experimental clones 317/1, 317/2, 317/3, 317/5, 317/6, 317/7 and 317/8 during Ju December is shown in Table 6.4.

Table 6.4. *Monthly population of red spider on experimental (china type)*

Clones	Number of red spider per 40 leaves in							
	June	July	Aug	Sept	Oct	Nov	Dec	Total
317/1	35	62	30	38	10	10	22	207
317/2	11	47	25	27	15	15	33	173
317/3	23	52	15	35	16	30	84	255
317/4	25	33	13	11	28	30	42	185
317/5	76	34	24	28	21	6	19	202
317/6	119	33	19	18	18	19	26	252
317/7	37	40	59	25	9	25	29	224
317/8	37	29	28	25	11	7	26	163

In general, 317/3 and 317/6 had a relatively mite population than 317/4 and 317/8 under parable condition. Rest of the clones were inter ate in so far red spider infestation was concerned. difference however was not formally significant, t a monthly variation in numbers on different clon noticeable. Causes for this variability will be st later as it could lead to a better selection of re clones.

Density of mite population in cold weath young and mature tea : Population densities spider, scarlet, pink and purple mites on young mature tea during cold weather (November to Jan was sampled to find out the distribution pattern of middle and lower zones of the leaf canopy of fifty (five years) and fifty mature (fifteen years) bushes. each bush nine leaves, three each from the three were randomly sampled.

Table 6.5. *Density of mite population in young and mature tea during dry months (November-January)*

Canopy zone	Mean mite population per leaf							
	Young tea				Mature tea			
	Red spider	Scarlet mite	Pink mite	Purple mite	Red spider	Scarlet mite	Pink mite	Purple m
Upper	0.29	0.02	0.46	3.38	0.82	0.40	3.15	5.62
Middle	0.71	0.19	0.43	4.01	1.14	0.30	2.82	4.72
Lower	0.39	0.42	0.09	1.59	0.71	0.59	1.02	2.70

During cold period mature tea had more population of all four species of mites than young tea both zonewise and on the bush as a whole (Table 6.5). Red spider population was at maximum in middle zone of both young and mature tea, but least on upper zone of young tea, and lower zone of mature tea. Density of scarlet mite was highest in lower zone of young and mature tea but least on upper zone of young tea, and middle zone of mature tea. Pink mite was maximum on upper zone and least on lower zone in both young and mature tea. Purple mite population was maximum in middle zone of young tea and upper zone of mature tea, but least in their lower zones. The difference in mite lation in different zones of young and mature te statistically significant ($P<0.05$). A practical i tance of these findings is that for effective control o pests the lower zones of the bushes have to be ad tely sprayed. Otherwise they may serve as f future infestation.

Effect of some insecticides on the predat red spider : A replicated randomized exper was carried out to find out whether Thiodan, Sum and Dursban have any toxic effect on the predat

red spider. Fortnightly observations were made during April to December on the incidence of red spider and its predators on 100 leaves from each treatment. The predators were virtually absent in all the treatments including control though there had been sufficient population of red spider in all the treatments: only insignificant predator population was noticed between mid-April and early May. This situation precludes any generalization on the toxic effects of insecticides on the predators of red spider.

Acaricidal spray and yield: Estimation of possible loss in yield due to red spider was assessed. A plot of Assam type of bushes was sprayed with Kelthane 18.5 EC at 0.23% concentration in May 1976 while a comparable plot was kept unsprayed. One week after spraying yield (in terms of green leaf) from these two plots was recorded every week till early December.

At the end of the year a 22% increase in yield in the treated plot was obtained (Fig. 6.2) (Table 6.6).

Table 6.6. *Yield in acaricidal treated and untreated plots*

Treatments	Yield (green leaf) per bush in gram in								
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Treated with Kelthane	39	224	199	226	244	202	42	9	1205
Untreated	35	194	148	177	190	200	35	6	985

Bushes with red spider under control gave continuously more yield than untreated bushes right up to September. After this, the yield difference between the plots was not highly significant.

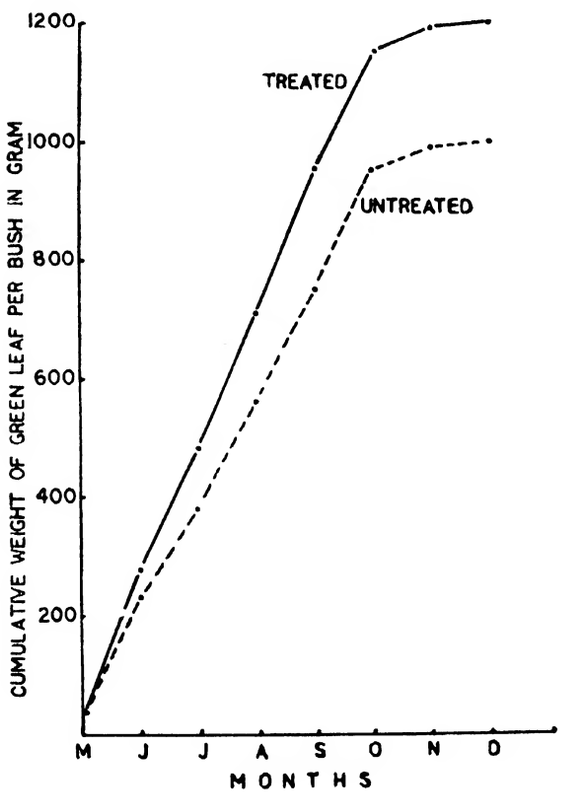


Fig. 6.2. Yield of tea from Kelthane treated and untreated plots

Effect of spraying zinc and the incidence of mites : This investigation was taken up in early 1976 to find out if spraying of zinc sulphate will influence mite multiplication. Bushes under comparable conditions (i.e. jat, age and agricultural practices) at Borbhetta were taken up with one set treated with zinc sulphate @ 24 kg/ha in four rounds, while the other was kept untreated.

The results are presented graphically in figure 6.3. From May onward there was a natural decline in mite population in both the treated and untreated plots. Inspite of this the populations of pink and purple mites were high between April and July in zinc treated plots; but no significant difference was noticeable in mite populations between August and March except in February when a rise in mite population in treated plots was noticeable.

Red spider population declined following an acaricidal spray in April in both treated and untreated plots: from July onward the population slightly increased in zinc treated plots.

Scarlet mite population increased from June but declined in October though there was an overall trend of more mite population in the zinc treated plots.

Shot hole borer

Shot hole borer (*Xyleborus fornicatus* Eich.) infestation was noticed in some estates in Mariani circle. Assessment shows that the incidence in general was low. Preliminary studies on its life-history in the laboratory show that the beetle completes its entire life cycle within the branches. The egg, larval and pupal stages were 7, 16 and 9 days respectively in May.

Field observations show this insect damages old tea in particular. Infested pockets were treated with four rounds of Endosulfan 35 EC (1:200) from May onwards after drastic pruning. This treatment reduced the intensity of fresh attack to a level of 4%. Observations on the biology of the beetle will continue.

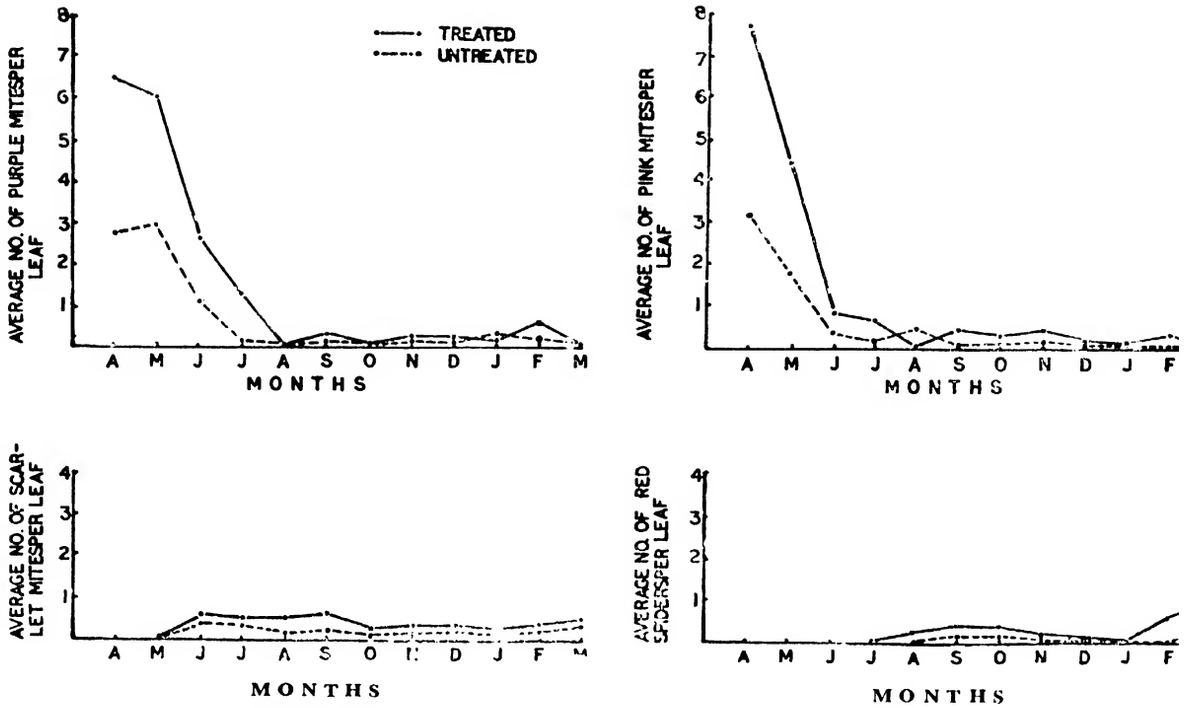


Fig. 6 3 Variation in population density of mites due to zinc sulphate application

Scale insect

Biological studies on red scale, *Aonidiella aurantii* (Maskell), *Velataspis serrulata* Ganguli and *Parlatoria proteus* (Curits) have been made in the laboratory.

Aonidiella aurantii (Maskell) causes severe damage to the V. P. cuttings and young plants and sometimes even mature tea. The female scale does not lay any eggs, but produces larvae directly. The life-cycle of the female larvae is completed in 32 days in April, 30 days in May and 26 days in June while in case of male the corresponding periods are 32 days, 28 days and 28 days respectively.

Velataspis serrulata Ganguli also causes severe damage to V.P. cuttings and young tea but rarely mature tea. Aggregations of the scales remain fixed to both stems and leaves. The female scale lays eggs inside the scale cover. The young larvae hatch out in 16 days in November, and 25 days in February-March. Life cycle of female is completed in 58 days and that of male in 81 days in November-January.

Parlatoria proteus (Curtis) mostly infests the leaves of V.P. cuttings and young tea. The female scale is oviparous. The young larvae hatch out in 18 days in November. The total duration of immature stages is 30 and 40 days for females and males respectively.

Darjeeling black hairy caterpillar

Euproctis latifascia Walk. Commonly known as Darjeeling black hairy caterpillar causes damage to young tea. Cuttings and seedlings are sometimes completely defoliated in beds or sleeves. It may also damage mature tea.

Studies on the life-cycle and development of pest have been made. Eggs laid in clusters are cove with buff coloured hairs. Eggs hatch in 12 days; caterpillar undergoes six moults before developing pupa. The total duration of life cycle (egg to ad was 86 days at 26.9°C with 74.8% RH.

Nematode

Population levels of *Meloidogyne incognita* in s and its effect on pathogenicity on tea seedling

Tea seddlings raised in steam sterilised sandy loam in sterilised earthen pots were inoculated with sec instar larvae of *M. incognita*. These larvae were isola from single egg mass culture on egg plants maintai in the greenhouse. The four levels of inoculum w 2, 4, 6 and 8 larvae per 10 g soil. Each inoculum le has ten replicates with one seedling in each pot.

75 days later the plants were uprooted, washed cl ned and the root system was scored for (1) total nu ber of galls, (2) total number of egg masses and degree of infestation.

Table 6.7. *Effect of different inoculum levels of M. incognita on pathogenicity on tea seedling*

Effect on plants / Inoculum level	Mean of 10 replicates: Total galls per seedling	Total egg mass per seedling	Degree of infestation
2 larvae/10 g soil	6.9	5.1	0.50
4 larvae/10 g soil	7.8	5.3	0.50
6 larvae/10 g soil	8.0	7.5	0.72
8 larvae/10 g soil	13.5	11.7	1.40

Results (Table 6.7) show that even at low inoculum of 2 larvae/10 g soil the seedlings sustain infestation. In view of this finding the threshold level for nematode damage is being reviewed.

Effect of temperature on hatching of the eggs of *M.incognita* : Equal number of freshly laid egg masses of *M. incognita* in glass blocks were kept in thermostats at 0°C and 14°C for 10 days.

Table 6.8. *Effect of change in temperature on hatching of Meloidogyne incognita eggs* (Figures are mean of five replications)

Initial temperature	Days	Percentage of hatching	Temperature raised to °C	Days	Percentage of hatching
0°C	0-10	0	30	10-20	94.53
14°C	0-10	0	30	10-20	97.50

Results (Table 6.8) show that neither at 0°C nor 14°C did the eggs hatch. When however the temperature was raised to 30°C, which is optimum for hatching, more than 90% eggs hatched within ten days.

Records of new host for root knot : The weeds recorded as new hosts of root knot are listed in table 6.9.

Table 6.9. *New hosts of Meloidogyne incognita*

Name of the host	Family	Common Assamese name	Degree of attack
1. *Polygonum perfoliatum* Linn.	Polygonaceae	Bagh asora	Mild
2. *Solanum indicum* Linn.	Solanaceae	Tita bhekoori	Moderate
3. *Drymaria cordata* Willd	Caryophyllaceae	Lai jabori	Moderate
4. *Brassica* sp.	Cruciferae		Mild
5. *Eupatorium odoratum* Linn.	Compositae	German babi	Mild

Laboratory trial of pathogenicity of two ectoparasitic nematodes on tea seedlings : Tea seedlings raised in steam sterilised sandy loam soil were inoculated with ectoparasitic *Helicotylenchus* sp. and *Rotylenchulus* sp. The level of inoculation was 500 nematodes per seedling with ten replications for each species. Another set of 20 pots with only sterilised soil were also inoculated with the two species of nematodes. A set of 10 pots with tea seedlings growings were kept as control i.e. without any nematodes inoculated into the soil.

75 days later the soils from inoculated and control series were processed for nematodes. The plants were measured for their height, weight, and their root systems were examined for presence of any nematode inside the root-tissues.

Results show none of the two species cause any material difference in the height and weight of the plants inoculated with them (Table 6.10).

Table 6.10. *Effect of two ectoparasitic nematodes on the growth of tea seedlings*

Treatment	Inoculated series		Non-inoculated series	
Nematodes	Soil and plant		Soil and plant	
	Plant height (cm)	Green wt. (g)	Plant height (cm)	Green wt. (g)
Helicotylenchus sp.	22.37	3.87	21.97	3.76
Rotylenchulus sp.	21.87	3.82	21.99	3.76

Screening and Evaluation of Pesticides

Toxicological studies in laboratory

Toxicological studies with X-factor, a chlorinated hydrocarbon, were conducted using cockchafer grubs (*Phyllophaga* (*Holotrichia*) *setticolis*). The insecticidal solution at 1 part in 300 parts of water by volume was applied in two different methods. First, the insecticide was applied to the surface soil in a wooden box in which the grubs were released prior to application of the insecticide. In the second method the grubs were introduced after the soil was treated with the chemical. Two observations, one week and four weeks after the application of the insecticide, were taken. By the first method a 90% mortality of the grubs was achieved and by the second method 95% mortality was recorded. Clearly the X-factor when applied before or after infestation with cockchafer grubs is quite effective in controlling the pest.

Pesticide evaluation under field conditions : Prophylactic application with Asakel, Asaethion, Ethion, Kilthane and a standard acaricide was made against red spider (*Oligonychus coffeae*). All acaricides were tested at 1.25 l/ha. These acaricides (Table 6.11) were equitoxic and the residual effect lasted for about a month.

Table 6.11. *Comparative efficacy of different Dicofol and Ethion formulations used prophylactically @ 1.25 l/ha against red spider*

Treatments	Toxic	Observation after 1 month	
	Concentration % (a.i.)	Mean population on 50 leaves	Percentage reduction over pre-treatment count
Asakel 18.5 E	0.116	14.50	72.98
Asaethion 50 E	0.313	24.50	76.44
Ethion 50 E	0.313	4.75	71.81
Kilthane 18.5 E	0.116	41.75	72.96
Ethion 50 E (Standard)	0.313	54.25	80.61
Least significant difference at P = 0.05		55.53	

Asated, Tetradifon, Asaethion, Ethion, Asakel and Tedion V-18 (as standard) when tested against red spider at 1 in 200 parts of water with mist blower showed

a significant promise and is in no way inferior to 1.25 l/ha. All the chemicals were equally effective in controlling red spider (Table 6.12).

Table 6.12. *Mortality of red spider with various acaricides sprayed at a dilution of* 1:200

Date of spraying : 10.3.77
Equipment : Mist blower power sprayer

Treatments	Observation after 1 month	
	Mean population per leaf	% reduction over control
Asated 818	0.00	100.0
Tetradifon	2.00	98.86
Asacthion	10.00	94.31
Ethion	27.67	84.25
Asakel	36.33	79.32
Tedion V-18	15.00	91.46
Control (untreated)	175.67	—
Least significant difference at P = 0.05	42.89	

Toxicological studies with Jassids

Field experiments with Ekalux, Anthio, Zolone vacron and Ethion all at a dilution of 1 in 200 pa water and a standard Endosulfan formulation at 200 and 1 in 266 were conducted against Jassids (*asca flavescens* Fabr.). Ordinary power sprayer used. The chemicals were equitoxic and gave control of Jassids: the mortality was in the range to 100% over the untreated control series two after application (Table 6.13).

Trials for Thrips control

The insecticides and dilutions applied in Jassid c were used to establish their efficacies against thrips (*Sericothrips dorsalis* Hood). Observation two weeks showed that Ekalux, Anthio, Nuva Ethion and Endosulfan, all at 1 in 200 parts gave reduction of thrips over control. Performance of

Table 6.13. *Comparative efficacy of different insecticides against Jassids and Thrips two weeks after application (Mean of three replications)*

Treatments	Toxic concentration % (a.i.)	Jassids		Thrips	
		Population per 10 leaves	% reduction	Population per 10 leaves	% reduction
Endosulfan 35 E	0.175	3.33	93.06	11.67	87.83
Endosulfan 35 E	0.131	6.00	87.50	23.67	75.26
Ekalux 25 E	0.125	0.00	100.00	0.33	99.65
Anthio 25 E	0.125	0.00	100.00	2.67	97.21
Zolone 35 EC	0.175	4.00	91.67	20.33	78.75
Nuvacron 40 E	0.150	0.33	99.31	0.67	99.30
Control	—	48.00	—	95.67	—
Least significant different at P 0.05		8.82	—	11.71	—

sulfan at 0.75 l in 200 litres was somewhat at variance with other treatments though better than control (Table 6.13).

Another series of control trial against Darjeeling thrips (*Taeniothrips setiventris* Bagnall) was conducted in Darjeeling with Ekalux, Anthio, Dursban and Endosulfan each at 1.25, 1.00 and 0.75 l/ha, and Dursban at 1.00, 1.25, 3.00 l/ha: in all cases the amount of water used was 200 l/ha which gave different toxic levels. Te a newly developed chemical, was also tried along the three insecticides at the rate of 4 gms per litre. servation after a fortnight showed (Table 6.14) th all the toxic levels Ekalux, Anthio, Dursban and E sulfan (except at 0.75 l/ha) were equally effective. tone gave a lesser mortality, though it is possible with a higher quantum of active ingredient it wil g better control.

Table 6.14. *Comparative efficacy of different insecticides against Thrips— 1976*

Treatments	Toxic concentration % (a.i.)	Living Thrips/25 shoots after			
		1 week		2 weeks	
		Living thrips	Reduction (%)	Living thrips	Reduction (%)
Ekalux 25 E	0.091	2.67	92.22	3.00	95.08
Ekalux 25 E	0.125	2.00	94.17	3.70	95.17
Ekalux 25 E	0.156	2.67	92.22	3.33	95.67
Anthio 25 E	0.091	6.00	82.52	2.33	96.96
Anthio 25 E	0.125	2.67	92.22	2.00	97.39
Anthio 25 E	0.156	2.33	93.21	1.00	98.69
Dursban 200 E	0.100	3.33	90.30	2.67	96.51
Dursban 200 E	0.125	2.67	92.22	2.67	96.51
Dursban 200 E	0.300	1.00	97.09	0.67	99.12
Endosulfan 35 E (Thiodan)	0.131	11.67	66.01	9.00	88.26
Endosulfan 35 E (Thiodan)	0.175	9.67	71.83	7.67	89.99
Endosulfan 35 E (Thiodan)	0.219	8.67	74.74	4.33	94.35
Tetone 25 WP	0.100	4.33	87.39	32.33	57.83
Control (untreated)	—	34.33	—	76.67	—
Least significant difference at P 0.05		7.61	—	7.42	—

Control of Scale insects

Against scale insects (*Eriochiton theae* Green) in Darjeeling seven commercial formulations of Malathion 50 EC and Diazinon 20 EC were tested at 1.25 l in 200 l of water. This gave toxic level of 0.313% and 0.125% for Malathion and Diazinon respectively. Assessment 2 weeks after spraying showed that these concentrations were equitoxic and the percentage reduction of scale insect population over the control was in the region of 88%-99%. The reason for the variability may be the differential mortality response of the different instars of the scale in the population.

Trial against looper

Nine commercial formulations of Endosulfan 35 EC were tested at 1.25 l in 200 l water/ha (0.219% a.i.) against Looper caterpillars (*Buzura* (*Biston*) *suppressaria*). All were equitoxic in controlling early looper caterpillars.

In another series, four different Endosulfan formulations, Fenitox, Ekalux and Anthio were tested at a similar rate as above. All endosulfan formulations, Fenitox and Ekalux gave over 90% mortality in a week's time. Anthio was somewhat slower in action and gave a mortality of 78% over the control one week after application.

Termite control

Trials were conducted in Cachar for the control of live-wood-eating termite (*Microcerotermes* sp.) using Dursban 20 E and X-factor, both at 10 l and 15 l/ha, and Endosulfan and Nuvacron at 10 l/ha were used. Assessment shows, even after one year the maximum reduction in the degree of infestation over the untreated control was 63% in X-factor treated plots. Further work is in progress.

Studies on Pesticide residue tolerance

Samples of manufactured and sun-dried tea treated with Omite 57 E, Nuvacron and Calixin have been processed for residue analysis. Results are awaited.

Pesticide Certification

23 Certificates of approval were issued to various formulations of plant protection chemicals. 22 Certificates were revalidated after bioassay studies. Agreements were made for formal testing of 18 formulations of various pesticides.

Advisory services

Soil samples and pest damaged materials were examined and reports were communicated to the estates. Out of 1300 soil samples about 11% were found unsuitable because of high eelworm population.

Quality control of pesticides

Quality control studies on different formulations of 39 acaricides and 7 insecticides received from a number of tea estates were made and reported.

During the year 1976-77 three new records of pathogenic fungi one fungus growing on nematode eggs and three new records of soil fungi are established. Use of lower doses of fungicides in disease control and successful control of primary root rots in the four year trials have also been investigated.

New finds

Armillaria mellea a fast killing primary root rot disease causing extensive damage in South India and Africa has been found to cause extensive deaths in Sikkim from where it was collected and identified. This appears to be the first record of its occurrence in tea in north east India.

Recently it was found to infect and kill an ornamental tree *Dombeya* sp. (Sterculiaceae) in Tocklai campus. Confirmatory tests of its species diagnosis are in progress. This flashes a danger signal even for the tea in the plains, which must be watched very carefully. The cardinal symptoms are bootlace like mycelium on the bark, a split in the collar region filled with white mycelia, and black lines in the wood.

Poria hypolateritia a primary root rot disease commonly known as red root rot is rather rare in N.E. India. It was found to kill a large number of bushes on a couple of gardens in Golaghat circle.

Rosellinia arcuata a primary root rot disease known to cause black root rot in Darjeeling area (rare in the plains), caused considerable damage on a couple of gardens in Upper Assam.

Anthracothecium manipurensis an ascolichen was collected and diagnosed from Darjeeling area on tea branches. It is not clear whether the lichen caused the die-back or its occurrence was a mere coincidence. Further studies are required to establish its pathogenicity. This appears to be the first record on tea.

Veritcillium catenulatum : a fungus was found occurring for the first time on nematode eggs.

Soil fungi : The following new records have been added to the list of soil fungi from N.E. India.

Aspergillus restrictus
Myrothecium leucotrichum
Verticillium chlamydosporium

RED RUST

Three experiments were laid out to study red rust control on gardens around Tocklai, in one of which screening of fungicides was undertaken to find out alternate, more economic and efficient fungicides than copper formulation. In the other two experiments various dilutions/doses of copper fungicides were studied using both hand operated and power sprayers to study efficiency of application and the role of dilution in control of red rust.

a) **Screening of fungicides :** Seven fungi including the conventional copper oxychloride (Bl were sprayed on susceptible clone TV 1 planted du 1969-70 in staggered double hedge using hand oper sprayers. The area had negligible shade, the di were dug and the tea was having uniform infectio the disease. Each treatment consisted of four r cates and each replicate had 50 bushes, untreated bl served as control. The first round of spray was imp on the 13th May 1976 after observing the sporan development and the last round was sprayed on 2 July 1976. The weather, on all the days of spra remained fair. The disease incidence was reco on 1st June 1977 to note the build up of disease.

Results are given in Table 7.1. Infection i dence or degree of infection per bush is estimated on normal 0-4 point scale.

Table 7,1. *Effect of chemotherapeutants on the red rust control (average of 200 bushes)*

Fungicide	Dilution	Rounds*	Infection/ bush	% reduction
Fungikill (B. D. Khaitan)	1: 600	4	0.83	70.67
Tamraghol (Vegfru)	1: 600	4	0.54	80.92
Copper oxychloride (Central insecticides)	1: 600	4	0.56	80.21
Kocide (Cupric hydroxide)	1: 600	4	0.55	80.57
Kitazine	1:1000	4	2.31	18.37
Blitox	1:1000	6	0.50	82.33
Blitox	1: 600	4	0.49	82.69
Tetone	1: 600	4	2.17	23.32
Control(unsprayed)	-	-	2.83	—
CD at p = 0.05			0.39	
CV%			22 36	

*In red rust when 4 rounds were given, the first 2 rounds were ap ed at fortnightly and the remaining 2 at monthly intervals. case of 6 rounds, applications were made at fortnightly interva

All the formulations of the dilutions used sign cantly controlled the disease with the exception of Tet and Kitazine. Amongst the successful formulati the highest percentage of reduction in disease, as co pared to the unsprayed, taking the infection rate the unsprayed as 100, was given by Blitox when spra in 4 rounds at 1:600 dilution or 6 rounds at 1:1 dilution. All the other fungicides that gave con were copper formulations.

b) **Protective action of copper fungicides :** T experiment was aimed at evaluating the protec action of copper fungicides when applied follow

previous cold weather pruning. The tea was a stand of mixed clones, planted in 1969 at 120 × 90 cm distance. The tea was heavily infected (pre-assessment infection rate was about 3.5) and was in a poor state, soil surface was uneven and the shade was practically absent. This experiment was started in 1975 and continued in 1976. First round of spray in 1976 was imposed on 20th May. Two blocks were separately sprayed; one with hand operated sprayers and the other with power sprayers. Fungicide used was Blitox at different dilution/doses. Each treatment was replicated four times and each replicate carried 25 bushes. The results are given in table 7.2 and 7.3 as average over 100 bushes.

Table 7.2. *Effect of copper fungicide application by hand sprayers in different dilutions on the red rust infection*

Blitox dilution	Rounds	Infection/ bush	% reduction
1:400	4	1:18	63.69
1:600	4	1:55	52.31
1:800	4	1:74	46.46
1:1000	4	2.00	38.46
1:1000	6	1.31	59.69
Unsprayed control		3.25	
CD at p 0.05		0.33	
CV%		11.9	

Control achieved by spraying 1:1000 in six rounds was similar to that obtained by 1:400 in four rounds and the difference was not statistically significant.

Table 7.3. *Effect of copper fungicide applied in different doses with a power sprayer on control of red rust (average of 100 bushes)*

Blitox dose/ha	Rounds	Infection/bush	% reduction
2.5 kg	4	1.07	69.69
1.875 kg	4	1.16	67.14
1.25 kg	4	1.62	54.11
0.625 kg	4	2.16	38.81
0.625 kg	6	1.34	62.01
Control (unsprayed)		3.53	
CD at p 0.05		0.26	
CV%		9.4	

Control of red rust with 0.625 kg/ha copper fungicide in six rounds with power sprayer was as effective as that obtained with 4 sprays of 2.5 kg/ha copper fungicide which was previously recommended.

The best overall control obtained in this experiment (b) was 70%; lower than that achieved in experiment (a) (83%). This may be attributed to the bush health and severe infection which was not properly treated prior to 1975. THIS EMPHASIZES THE FACT THAT THE BUSH HEALTH IS AS IMPORTANT AS THE CHEMOTHERAPY IN THE EFFICIENT CONTROL OF RED RUST.

BLACK ROT

During 1976-77 three field experiments were carried out on commercial estates to study black rot control. Two experiments with ten treatments were designed to test the efficacy of different fungicides while the third was meant to check the effectiveness recorded in 1975-76 with different dilutions of a standard copper fungicide.

Experiment 1. Screening of fungicides : The first experiment was carried out in a garden near Titabar where mature tea bushes were found to carry moderate to severe infection by the disease. The tea was planted at 150 ×60 cm where ten treatments including the untreated control were randomized in three replications, each plot consisting of 46 plants. Two applications were made at fortnightly interval using hand operated Bakpak sprayers. The first round was applied on 21st May on observing the active growth of the causal organism, and the second on 4th June 1976. The plots were separated by guard lines. Observation on the degree of development of the disease was made on 22.7.76 and the results are represented in Table 7.4.

Table 7.4. *Effect of fungicides on the control of Black rot (average of 138 bushes).*

Fungicide	Dilution	Rounds	Infection/ bush	% reduction
Fungikill	1: 600	2	0.38	67.24
Tamraghol	1: 600	2	0.41	64.66
Copper oxychloride(Central Insecticides)	1: 600	2	0.38	67.24
Kitazine	1:1000	2	0.78	32.76
MBC	1: 600	2	0.63	45.69
Tetone	1: 600	2	0.78	32.76
Calixin	200 ml/ha	2	0.67	42.24
Lorvek	1: 600	2	0.99	14.66
Blitox	1: 600	2	0.34	70.69
Control		—	1.16	
CD at p 0.05			0.32	
CV%			28.46	

Blitox when applied in two fortnightly rounds at 1:600 offered the best protection (70.69%) followed by copper oxychloride (67.24%), fungikill (67.24%) and Tamraghol (64.66%). All these four are copper formulations. Least protection was given by Lorvek (14.66%).

The results indicate that only copper fungicides gave appreciable control.

Experiment 2 The same treatments were repeated on another garden where the disease infection was found to be higher than observed in the area where the preceding trial was located. The bushes were spaced 150×60 cm and were younger (11 years old). Plots were however smaller in size consisting of 20 bushes each. There were three replicates. The first application was made on 24.5.76 and the second round could be applied after three weeks on 14.6.76 because of incessant rain during the intervening period. Observation on the degree of incidence of the disease (average of 60 bushes) is given in Table 7.5.

Table 7.5. *Effect of fungicides on the control of Black rot.*

Fungicide	Dilution	Rounds	Infection/ bush	% reduction
Fungikill	1: 600	2	0.40	71.43
Tamraghol	1: 600	2	0.43	65.71
Copper oxychloride (Central Insecticides)	1: 600	2	0.38	72.86
Kitazine	1:1000	2	0.87	37.86
MBC	1: 600	2	0.95	32.14
Tetene	1: 600	2	0.60	57.14
Calixin	200 ml/ha	2	0.92	34.29
Lorvek	1: 600	2	0.93	30.00
Blitox	1: 600	2	0.23	83.57
Control (unsprayed)			1.40	
CD at p 0.05			0.37	
CV%			30.24	

In this experiment also none of the non copper formulation was found to be effective. The results are similar to those obtained in the previous experiment (cf. table 7.4).

Experiment 3. Effect of different dilutions with hand sprayer : In a previous experiment (Ann. Rep. 1975-76, p.39) it was observed that Blitox (a copper oxychloride formulation) applied at one in 800 dilution in combination with sticker Pinolene-NU-Film 17 gave a high degree of control but the sticker imparted a taint to tea. Hence Triton AE was used in place of Pinolene in this year's experiment. There were altogether eight treatments randomized in three replications, each plot consisting of 36 bushes. The number of treatments in 1975-76 was seven. The first round was applied on 24th May and the second round three weeks later as spraying had to be postponed because of heavy rain during the time when it was due two weeks later. While spraying, Bakpak sprayer was used.

The effect of the treatments as judged by the degree of incidence of the diseases per bush is shown in table 7.6.

Table 7.6. *Effect of Blitox at different dilutions and rounds on Black rot incidence (Mean of 108 bushes).*

Fungicide	Dilution	Rounds	Infection/ bush	%reduction.
Blitox	1: 400	2	0.39	67.23
,,	1: 600	2	0.45	62.18
,,	1: 800	2	0.74	37.82
,,	1:800 + Triton	2	0.60	49.58
,,	1:1000	2	0.81	31.92
,,	1:1000 + Triton	2	0.83	30.25
,,	1:1000	4	0.56	52.94
Control unsprayed			1.19	
CD at p = 0.05			0.22	
CV%			17.58	

It is seen that the dilution viz. 1 in 800 which was found to be effective in 1975-76 when applied with Pinolence did not indicate much benefit when applied with Triton as sticker and therefore it is felt that there is very little scope to use a copper fungicide at this dilution (1:800) for the present. 1:400 and 1:600 offered almost similar control. It appears from these resu that 1:600 can be beneficially tried out which v enable saving of fungicide.

BLISTER BLIGHT

In 1976 altogether three experiments were carried o in Darjeeling to test the efficacy of some new copp formulations along with a new systemic fungicide Cali in different combinations with Mowlith as a bind (Sticker). Power sprayers were used in two trials a hand sprayer in one. In one experiment effect on yie was also considered.

Experiment 1 : This trial was conducted using ha sprayers. Copper fungicides were used at 1 in 8 parts of water and Calixin was used with Mowlith 1:4 ratio and the dilution of the combination was adjusted as to give 200 ml. Calixin per/ha per roun There were altogether 6 treatments including the u sprayed control. These were randomized in four re licates. Each plot consisted of 40 bushes. Shoots we plucked from each plot, bulked and 100 shoo were collected from each bulk sample. Total number blisters were counted on the shoots. Spraying was do immediately following a plucking round at 7 day inte val. In case of Calixin the spray interval was 14 da Results are given in Table 7.7.

Table 7.7. *Effect of different fungicide on incidence of Blister per 100 shoots.*

Fungicides	Rate	Spray frequency: Inter-val (Days)	Rounds	Blisters/100 shoot: Number	% reductio n
Calixin with Mowlith (1:4) (Prophylactic)	200 ml/ha	14	3	160.25	44.31
Calixin with Mowlith (1:4) (Palliative)	200 ml/ha	14	2	156.75	45.53
Fungikill	1:800	7	4	35.25	87.75
Tamraghol	1:800	7	4	28.75	90.00
Blitox	1:800	7	4	60.00	79.14
Control				287.75	
CD at p = 0.05				53.40	
CV%				29.18	

Here only the copper fungicides have given hig degree of control (between 90% & 80%). Calixin i this experiment gave only about 46% control, thoug in the next experiment control up to 81% was obtai ned. This will be rechecked during 1977-78 season

Experiment 2 : In this trial seven treatments includ ing the control was randomized in four replications each plot consisting of 40 bushes. Power sprayer wa used. The spraying was started on 9.7.76 and the las round was given on 30th July 1976. The method o assessment was same as described in the preceding experiment.

Results are given in Table 7.8

Table 7.8. *Effect of fungicides on incidence of blister per 100 shoots (Mean of 4 replicates)*

Fungicides	Rate/ha	Interval in days	Rounds	Mean blisters/ 100 shoots	%reduction
Blitox	625 g	7	4	23.25	85.62
Tamraghol	,,	7	4	28.00	82.68
Copper Oxychloride	,,	7	4	26.25	83.77
Fungikill	,,	7	4	27.75	82.84
MBC	,,	14	2	130.25	19.47
Calixin + Mowlith	200 ml	14	2	31.00	80.83
Control				161.75	
CD at p = 0.05				55.05	
CV%				60.58	

As the CV% was high the original figures were transferred to log value and are given below :

Treatment No. 7—2.19940
Treatment No. 5 2.05405
Treatment No. 6—1.48117
Treatment No. 4—1.40698
Treatment No. 3 1.39136
Treatment No. 2—1.36646
Treatment No. 1 —1.36466
CD 0.05 = 0.26832
CV% 11.22

The result is in conformity with what is apparent from table 7.8 but it has been reduced to an acceptable level by using log transformations. All the fungicides excepting MBC were found to be highly effective in reducing the disease.

Experiment 3 : In the third trial all the treatments in the second trial were included. In addition, Calixin was used with Mowlith at 1:2 and 1:3 ratio. Hard plucking was one of the treatments. Plot size was of 48 bushes in 3 rows of 16 bushes each. The treatments were randomized in 3 replicates. Spraying was done with power sprayer. Here upto six rounds were applied. Initially two rounds were applied and then the weather became bright and sunny. The infection level went down by itself. Subsequently weather deteriorated and spraying was resumed. Copper fungicides were sprayed at weekly interval while two rounds of Calixin at 14 day intervals were sprayed—the first was given on 19.7.76 and the 6th and last on 30.8.76.

As this experiment is aimed at estimating the effect of the treatments (disease control) on yield, pre-treatment yield records were taken during the back end season of 1975. Yield figures for 1976 were recorded and it is intended to continue recording of the same for a complete pruning cycle.

The effect of the teatments on incidence of blister blight for the season 1976 is given in table 7.9.

Table 7.9. *Effect of chemical control on blister blight incidence (a week after the 6th round of copper fungicide)*

Fungicide	Dose	Interval in days	Rounds	No. blisters 100 shoots	% reduction
Blitox	625 g/ha	7	2+4	74.33	75.28
Fungikill	,,	,,	,,	72.67	75.83
Tamroghol	,,	,,	,,	76.67	74.50
Copper oxychloride	,,	,,	,,	61.67	79.49
Calixin[1] + Mowlith[2]	200ml/ha	14	1+2	174.33	42.02
Calixin[1] + Mowlith[3]	,,	14	,,	235.33	21.73
Calixin[1] + Mowlith[4]	,,	14	,,	205.33	31.71
MBC	625/ha	14	,,	425.33	
Hard plucking (weekly throughout the observation)				120.67	59.87
Control				300.67	
CD at p = 0.05				75.17	
CV%				25.08	

Copper fungicides were very effective in controlling the disease. MBC was not at all effective whereas Calixin was very much less effective and gave contradictory results. Hard plucking also contained the disease.

Considering the three trials, copper fungicides are still best for control of blister while Calixin required further trial to elucidate its effectiveness in the second trial and comparatively poor performance in the other two.

BRANCH CANKERS

The effect of chemotherapeutant in control of *Poria* and *Aglaospora* are under study as follows :

Date applied	Chemicals used	Causal organism	Locations
12.1.74	PP 395 (ICI)	*Aglaospora*	Happy Valley
11.3.75	Pancil T (Indofil)	*Poria*	Tocklai
	Coal Tar	*Poria*	,,

Results so far obtained indicate the following :

a) *Aglaospora* : From the observation there is no difference between the treated and the untreated bushes in infection rate. This will be further observed this cold weather (1977).

b) *Poria* : Pancil T appears to be inferior to Coal Tar (Indopaste) in its protective action.

PRIMARY ROOT ROTS

Soil fumigation studies in control of primary root rot diseases caused by soil borne fungi have been under observation. The oldest of the experiments is about 3 years old. The technique of soil fumigants was to uproot *only* the dead bushes (and not the apparently healthy bushes as suggested in the T.E. Serial No. 70/1 filed under I.3.) and inject the fumigant/add the chemicals. The formulations studied so far are the following with rates indicated against each :

1.	Vapam Metham sodium	8 ml/per perforation	30 cm apart to a depth of 20 cm.
2.	Dichloroethane	-do-	-do-
3.	Telone	-do-	-do-
4.	Shell DD	-do-	-do-
5.	Calixin	1 lit/ha	Soil drench
6.	Bavistin	1 kg/ha	-do-
7.	Lithium chloride	1 g/100 sq. ft.	-do-

Following is the list of garden on which the experiments have been laid out with dates of appication.

1.	Naharkutia T.E.	February 1974
2.	Balasun T.E.	September 1974
3.	Borhat T.E.	January 1975
4.	Thakurbari plots	May 1975
5.	Tarajuli T.E.	June 1975
6.	Dilli T.E.	April 1976
7.	Borbhetta	September 1976

In addition many gardens have undertaken soil fumigation studies under our guidance with great satisfaction.

The replanting in all the experiments has been done after the 12th week.

The soil fumigation was done into the next apparently healthy ring of bushes taking care not to apply the chemicals too close to the collar (a distance of 15-20 cm from collar is safe). In one of our experiments phytotoxic symptoms leading to death of two plants resulted where the chemicals were applied too close to the collar region.

There was no death recorded in the fumigated areas and from the treated apparently healthy bushes.

Soil fumigation/treatment is most suitable to eliminate root rot diseases from small patches noticed in the midst of young and high yielding teas. Economically it is not found to be very useful in treating areas over 1 acre in a patch. Vapam (Metham sodium) when applied at 8 ml/hole, an acre would require about 350 litres in which the chemical itself would cost around 4000/- (I.C.I. is selling Metham sodium at about 11/- per litre) plus the application costs. Calixin is sold around Rs. 185/- a litre but its long range effect is yet to be examined. It is proposed to examine the alteration in the soil microflora brought about by the fumigants. Probably the root rot pathogen may not be completely eliminated from the soils but the increased saprophytic activity of the soil fungi might be depriving the root rot pathogens their required carbohydrate supplies by utilising the sources extravagantly. From the past experiments undertaken on the survival of the pathogens it appears that they are very economic and miserly consumers of the starch materials. This is the possible explanation for the slow death of the plants affected by the root rot diseases. These experiments will continue.

Biological nitrogen fixation

For further studying in the possibility of nitrogen fix by non-symbiotic bacteria in tea soils, an experi was conducted by inoculating the commercial as as pure isolates into air-dried soils collected from bhetta, filed into pots. The pots were amended the bio-fertilizers as suggested by the manufactu The pure culture were added to soil upon growin nutrient medium (Jenson's medium). The soils kept moist by adding water.

Nitrogen estimations were made by Kjeldahl thod at regular intervals. The nitrogen estimat were made prior to applying the bio-fertilisers, to k the native nitrogen levels.

The results did not show any significant addi of nitrogen into the soils. It may be reiterated (as reported in Annual Report 1975-76, p. 41) that ability to fix nitrogen into acidic soils is poor and that activity of *Beijerenckia* and *Azotobacter* goes d in the presence of available nitrogen in the soils. bhetta soils have a native nitrogen content of 0.8-0. The following were studied :

1. Nitrobacter — Biocultures Mfg. Lab.
2. Azotobacter — Shaw Wallace
3. Mutant Azotobacter — Shaw Wallace
4. Bacterial fertilizer given by Mr. D. N. Barl
5. 8000/6 Beijerinckia sp. from Jabalpur } Obtaine
6. 8000/8 Beijerinckia sp. from Russia } from I.A

Soil Microbiology : A C.S.I.R. fellow is work on "the effect of agro-chemicals on the Microbiol of tea soils" for Ph.D. degree. Following is the out of the work so far completed.

a) **Standardisation of media :** From among different media studied for the best growth in isolat and pure culture studies, Rose Bengal-streptomy agar was the best for isolation of fungi; Thornto medium was best for bacteria and glycerol-asparag medium for actinomycetes.

b) **Distribution of fungi in the vertical scal** Analysis of soil to a depth of 90 cm from the surf revealed that most of the dominant flora existed upt depth of 1-23 cm below which there is marked decl in numbers. On the basis of this findings soils for ana sis were grouped into 1-23 cms, 24-50 cms and 51-90 c depth. Evaluation of flora was made from virgin and soil carrying tea of different ages.

c) **Soil flora :** Soil flora was estimated from ar carrying tea that were treated with fertilizers, insecticic acaricides, fungicides and herbicides. Areas stud had tea of age groups 0-5 years, 6-10 years, 11-15 yea 16-20 years and above 20 years. It may be mentior that *Sphaerostilbe repens*, the causal organism of Vic root rot was frequently isolated from tea soils in th present study.

Processing of green leaf to made tea was reflected by changes in the pigment profiles which also served as an index for the degree of fermentation. Second flush teas showed high amount of theaflavins which are known to contribute towards the quality of tea.

45 and 180 kg/hectare of potash application appeared to have slight adverse effect on the quality of tea compared to no application of potash.

Two factory floor tests developed for ascertaining the corect fermentation times for C.T.C. and Orthodox teas were found useful.

Pigment profile

(i) **Clonal behaviour in flushes**

Characterisation of the different flushes from the study of the pigment profiles of made teas have already been reported for a number of TV clones (Ann. Rep. for 1973-74, 1974-75 and 1975-76). Two more clones TV 10 and TV 19, were studied during this season using the technique described in the previous reports.

As leaves from these two clones were available only from June onwards, the first flush characters were not observed in the pigment profiles. The profiles showed second flush characters upto the first week of July. The characters of the rains flush dominated till the end of the first week of September. It was evident that in a majority of cases, the profiles for both the clones were of a similar nature. The total oxygen uptake figures of unprocessed shoots of the two clones lended added support to these observations, which the Tea Tasters also corroborated.

It was further observed that some of the clones attained the second flush character somewhat earlier in the season, which others did at a later period. Furthermore, the durations of different flushes varied from season to season, depending upon the prevailing agroclimatic conditions.

(ii) **Pigment profiles at different stages of leaf processing**

An experiment was caried out to determine the changes in the pigment profiles at different stages of manufacture. Fresh leaf, withered leaf and rolled leaf of clones TV 10 and TV 19 were used for this experiment.

The profile for fresh leaf showed two peaks at D_1 and D_2 of Fig. 8.1. On chromatography of the fractions corresponding to the two peaks, D_1 and D_2, it was observed that D_1 fraction contained chlorophyll, chlorogenic acid, gallic acid, catechins, etc., whereas D_2 fraction contained mainly the catechin gallates.

The withered leaf profile also showed the same two peaks (Fig. 8.1), with the difference that the D_2 peak was flattened. In some cases, the withered leaf profiles were somewhat similar to those of made teas. This could be attributed to slight fermentation of the withered leaf due to partial damage of the leaf during transporatation from field to factory and withering.

The extract of rolled leaf showed three other peaks, A, B and C, in addition to D_1 and D_2 (Fig. 8. 1). Since the D_1 and D_2 peaks were much flattened in this profile, it can be inferred that the additional peaks A, B and C originated from them (D_1 and D_2) as a result of rolling which caused fermentation of the leaf for about half an hour. The A, B and C peaks corresponded to higher polymers of catechins (e.g. thearubigins), showing that fermentation taking place during rolling initiated the process of polymerisation of the polyphenols, which will continue until completion of the fermentation process.

The study of the pigment profiles were carried out at the wave length of 380 nm only. It is intended to examine the eluates at a range of wave lengths to obtain more information of their chemical composition, when such facilities are available.

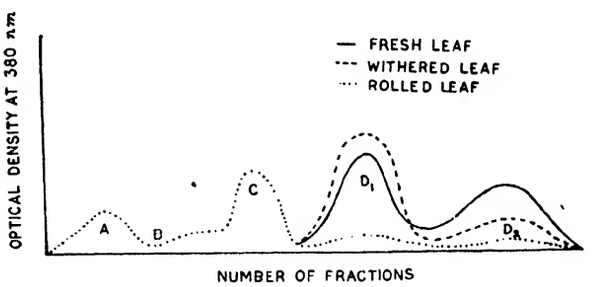
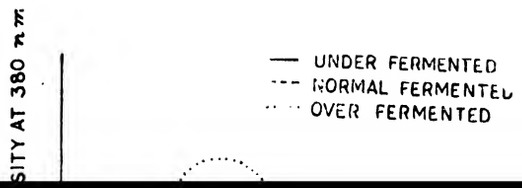


Fig. 8.1. Pigment profiles of fresh, withered and rolled leaf

(iii) **Pigment profiles as influenced by length of fermentation**

Leaf processed by the C.T.C. method and fermented for different lengths of time were subjected to pigment profile analysis to determine the profile characteristics of under-fermented, over-fermented and normally fermented made teas. Leaf from clones TV 10 and TV 19 rolled by the C.T.C. method were fermented for 1 h, 1 h 20 m, 1 h 40 m and 2 hours and the made teas were analysed for pigment profiles. Results for under, normal and overfermented made teas are presented in Fig. 8.2.

The underfermented teas showed larger peaks at A, B and C compared to those of rolled leaf of Fig. 8.1, indicating increased polymerisation of the catechins. The peaks, A, B and C increased in size with the advance of fermentation, at the expense of the D_1 and D_2 peaks, which became smaller. It was, however, observed that in general 1 h 40 m to 2 h fermentation was necessary for leaf from these two clones to produce the desired profiles for properly fermented teas.



shoots from the three potash treatments were collec
at weekly intervals and were analysed for chloroph
amino acids, enzyme (oxidase) activity and total oxyg
uptake. The leaf from the experimental plots w
manufactured at the same time by the C.T.C. meth
The corresponding made teas were analysed for

Table 8.3. *Average amino acid contents of the plucked shoots of clone TV 2 under different doses of potash manuring*

Doses of potash kg/ha	Amino acids (mg/100 g dried leaf)			
	Theanine	Glutamic acid	Other amino acids	Total
0	1470.9	234.3	296.2	2001.4
45	1357.0	283.6	329.8	1970.4
180	1267.8	285.0	328.2	1881.0

(iii) Enzyme activity and total oxygen uptake

The average enzyme activity in the plucked shoots over the whole season remained almost the same for the three levels of potash manuring, thereby indicating absence of any effect of potash manuring on the activity of the oxidase enzymes.

The monthly average figures for total oxygen uptake (μl O_2/mg/2h) of plucked shoots from the three levels of potash manuring are graphically represented in Figure 8.3. The corresponding valuations of the teas by Tocklai and Calcutta tasters are shown in Figure 8.4.

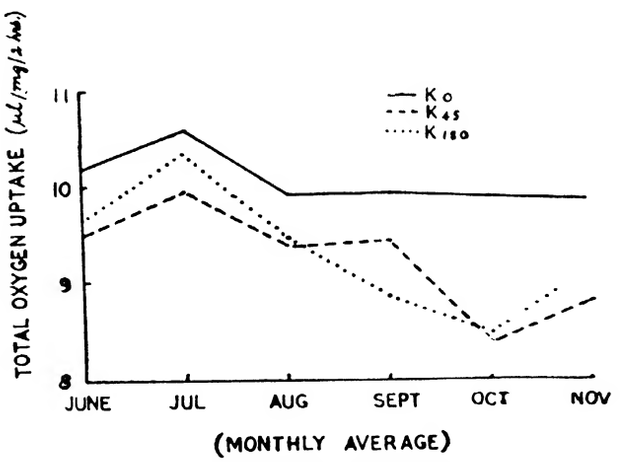


Fig. 8.3. Total oxygen uptake of plucked shoots of clone TV2 from three levels of potash manuring

The total oxygen uptake in shoots from the no potash plots was found to be somewhat higher than those from 45 kg and 180 kg/hectare potash plots throughout the experimental period from June to November. Except for a slight variation during the period from June to August, the oxygen uptake remained practically the same from August onwards to end of November in the no potash plot, while in the two potash plots the uptake showed a tendency to decline from July to October followed by a slight rise in November. The total uptake of oxygen reflected the concentration of the substrates, the polyphenols present in the leaf. It appears that application of potash causes a slight decline in the concentration of the substrates. This, in turn, is reflected on the TF and TR contents (Table 8.4) of the corresponding teas.

(iv) TF and TR contents

The average TF and TR contents of the C.T.C. teas manufactured from leaves drawn from plots under the three levels of potash manuring are presented in

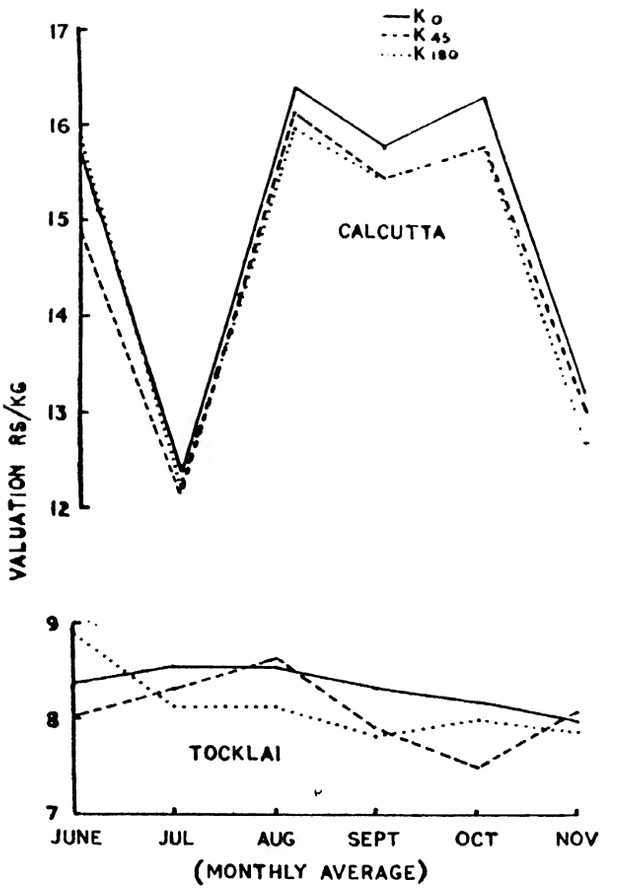


Fig. 8.4. Tasters' valuations of made teas of clone TV 2 under three levels of potash manuring

Table 8.4. TF and TR values were the highest in the teas made from the no potash plots, while there was no difference in TF and TR between teas from 45 kg and 180 kg/ha potash plots.

Table 8.4. *Average values of TF and TR and valuations of C.T.C. teas manufactured from the leaf of clone TV 2 under different doses of potash manuring*

Doses of potash kg/ha	Percent TF	Percent TR	Percent TF+TR	TF/TR	Valuations Rs/kg	
					Tocklai	Calcutta
0	2.54	15.82	18.36	0.163	8.33	15.31
45	2.31	15.60	17.91	0.150	8.11	14.91
180	2.31	15.24	17.55	0.151	8.15	15.07

The average valuations given by the tasting panels at Tocklai and Calcutta were slightly higher for teas made from the no potash plots than from those receiving 45 kg and 180 kg potash per hectare. There was hardly any difference in the average valuations of teas from the 45 kg and 180 kg/ha potash plots.

Changes of amino acid levels during black tea manufacture*

Changes of amino acid levels during different stages of manufacture of black tea viz. withering, fermentation and drying were studied. The results showed that

* The study is in partial fulfilment of Ph.D. thesis of Mr. M. N. Dev Choudhury

during normal withering the concentration of amino acids definitely increased as a result of breakdown of proteins to free amino acids by the specific enzyme "Protease". Fermentation of the leaf caused some degradation of the amino acids. The extent of deg dation of amino acids as a result of fermentation found to be higher in Orthodox compared to that C.T.C. manufacture (Table 8.5).

Table 8.5. *Changes of amino acid levels (mg/100 dry leaf) during withering and fermentation of the Assam Tea leaf (Clone TV 15)*

Amino acids	Fresh leaf	Withered leaf	Fermented leaf	
			C.T.C.	Orthodox
Aspartic acid	140.2	330.6	269.7	206.1
Glutamic acid	255.5	352.6	189.6	223.5
Serine	31.2	43.5	34.7	34.8
Asparagine	—	308.6	304.4	213.6
Threonine	8.5	13.1	11.8	9.1
Lysine	6.8	36.4	23.1	15.4
Glutamine	62.3	125.9	120.2	89.4
Alanine	19.0	27.0	20.0	19.0
Tyrosine	7.5	31.5	32.0	22.9
Leucine/Isoleucine	5.2	91.3	88.1	74.5
Phenylalanine	9.4	132.2	101.1	84.4
Valine	13.5	116.5	101.5	95.4
Theanine	1301.3	1536.9	1155.6	953.6
Total	1860.4	3196.1	2454.8	2041.7

The decrease in the concentration of different amino acids during fermentation is primarily due to deamination and decarboxylation resulting into the formation of the corresponding aldehydes (Popov, V. R. 19 *Biokhimiya*, 21, 380-384).

The overall changes of amino acids during fermen tion and drying are recorded in Table 8.6.

Table 8.6. *Changes of amino acids levels during manufacture of black tea (mg/100 g dry tea)*

Amino acids	Clone 126 A			Clone TV 1 (Unpruned)			
	Fresh leaf	Withered leaf	C.T.C. Tea	Fresh leaf	Withered leaf	C.T.C. Tea	Orthodox Tea
Aspartic acid	168	240	171	18	168	186	135
Glutamic acid	432	390	267	141	150	168	159
Serine	60	101	65	29	60	41	42
Threonine	—	—	—	11	14	12	13
Asparagine	—	240	162		192	174	174
Glutamine	183	228	135	40	99	29	26
Alanine	30	36	36	18	23	29	29
Tyrosine	16	65	44	17	18	16	17
Leucine/Isoleucine	15	87	57	14	72	51	48
Phenylalanine	15	102	60	23	114	57	84
Valine	12	96	60	14	78	60	60
Theanine	1022	1109	1037	432	570	346	317
Total	1953	2694	2094	820	1558	1169	1104

The decrease of amino acid content during drying may be partly due to decarboxylation and partly for non-enzymatic browning reaction involving sugars and amino acids during heat treatment.

Factory floor fermentation test

(i) By use of phenol reagent

Tocklai Fermentation Test (T.F.T.) as develope in the laboratory (Ann. Rep. 1975-76, p 44) to ascertai the correct fermentation time of tea leaf was conducte on miniature scale manufacture in the Tocklai Factory

The test was later modified to suit the conditions of large scale manufacture in tea estates and the modified test was carried out in four commercial tea factories. The modified test for commercial manufacture has been published in Two & A Bud, 1976, **23** (2), p 50.

The object of developing such factory floor test is to lay a scientific basis for tea fermentation and to replace the subjective way of assessing the progress of fermentation from the colour and the 'nose' of the fermenting leaf. Some results obtained with this test in respect of leaf processed by the Orthodox and C.T.C. methods are presented below.

Orthodox manufacture

Some results of the Fermentation Test carried out in a commercial factory doing orthodox manufacture are presented in Table 8.7. The optical density (O.D.) measurements at 700 nm and the corresponding valuation of teas from the 1st, 2nd and 3rd fines and from the coarse mal are shown in the table.

Table 8.7 *Optical Density (O.D) measurements at 700 nm of Orthodox leaf and the corresponding valuations of the made teas*

Fermentation time	1st fine		2nd fine		3rd fine		Coarse mal	
	O.D.	Valuation of tea Rs./kg	O.D.	Valuation of tea Rs./kg	O.D.	Valuation of tea Rs./kg	O.D.	Valuation of tea Rs/kg
2 h 20 m	0.48	9.00	0.48	9.00	0.50	6.50	0.40	6.50
2 h 30 m	0.41	8.50	0.45	8.50	0.54	8.00	0.42	8.00
2 h 40 m	0.40	8.00	0.41	8.00	0.50	7.50	0.44	8.50
2 h 50 m	0.39	7.00	0.43	7.50	0.44	6.50	0.36	7.00
3 h							0.30	6.25

C.T.C. manufacture

The Tocklai Fermentation Test, developed specially for the Orthodox method of processing, was also tried for C.T.C. manufacture with slight modification (Two & A Bud, 1976, **23** (2), p 50). The test was conducted at intervals of 5 minutes. A set of results from one such experiment is presented in Table 8.8.

Table 8.8 *Optical Density (O.D.) measurements at 700 nm for C.T.C. leaf and the corresponding valuations of the teas*

Fermentation time	O. D.	Valuation of tea Rs./kg
1 h 10 m	0.16	13.40
1 h 15 m	0.18	13.60
1 h 20 m	0.21	13.30
1 h 25 m	0.26	13.80
1 h 30 m	0.25	13.70
1 h 35 m	0.21	13.50

Since this test does not account for the fermentation which goes on during drying of the fermented leaf, improper drying of the leaf may adversely affect the quality of the tea even after achieving correct fermentation at the time of transfer of the leaf to the drier. This is one of the reasons for which certain anomalies were observed in tasters' valuations of under and over-fermented teas, specially in the C.T.C. method of manufacture.

(ii) **By measurement of TF**

Attempts were mae to develop an alternative chemical test to follow up the fermentation process during C.T.C. manufacture. The test was based on the measurement of the colour intensity of theaflavins (TF) formed during fermentation of the tea leaf.

Previous study had shown that both theaflavins (TF) and thearubigins (TR) start forming with the initiation of fermentation during rolling of tea leaf. The concentration of TF goes on increasing with the progress of fermentation till a stage is reached after which there is no more formation of TF. On prolonging the fermentation, the TF content ultimately shows a slight decline. On the other hand, the concentration of TR goes on increasing with the increase of fermentation time. Properly fermented leaf should have a high concentration of TF and an adequate amount of TR. It was therefore felt that if the concentration of TF can be measured by a simple test at different stages of fermentation, it may be possible to pin-point the correct fermentation time.

An infusion of 5 g of fermenting leaf was made with 150 ml boiling water and kept covered for 3 minutes after which it was filtered through cotton wool. 5 ml of the infusion was mixed with 5 ml of 1% aqueous solution of anhydrous disodium hydrogen phosphate in a separating funnel. The mixture was shaken vigorously with 5 ml of ethyl acetate for 1 minute and the two layers allowed to separate. The lower aqueous layer was drained off and 5 ml of ethyl acetate was added to the coloured extract. The extract was then transferred to a test tube.

The test was repeated at intervals of 10 minutes of fermentation and the intensity of the coloured extracts was judged visually by viewing vertically through the length of the column of the liquids in test tubes against a white background. By careful examination of the solutions it was possible to distinguish the intensity of colours. However, for a precise estimation, the intensity of the colours could be measured at 460 nm in a colorimeter.

This test was conducted on miniature scale manufacture and the tea samples corresponding to each test were evaluated by tea tasters. The average O.D. figures for 2nd flush, rains and autumn flush leaves of clones TV 2 and TV 18 are graphically represented in Figures 8.5 and 8.6 along with the corresponding average valuations of the made teas.

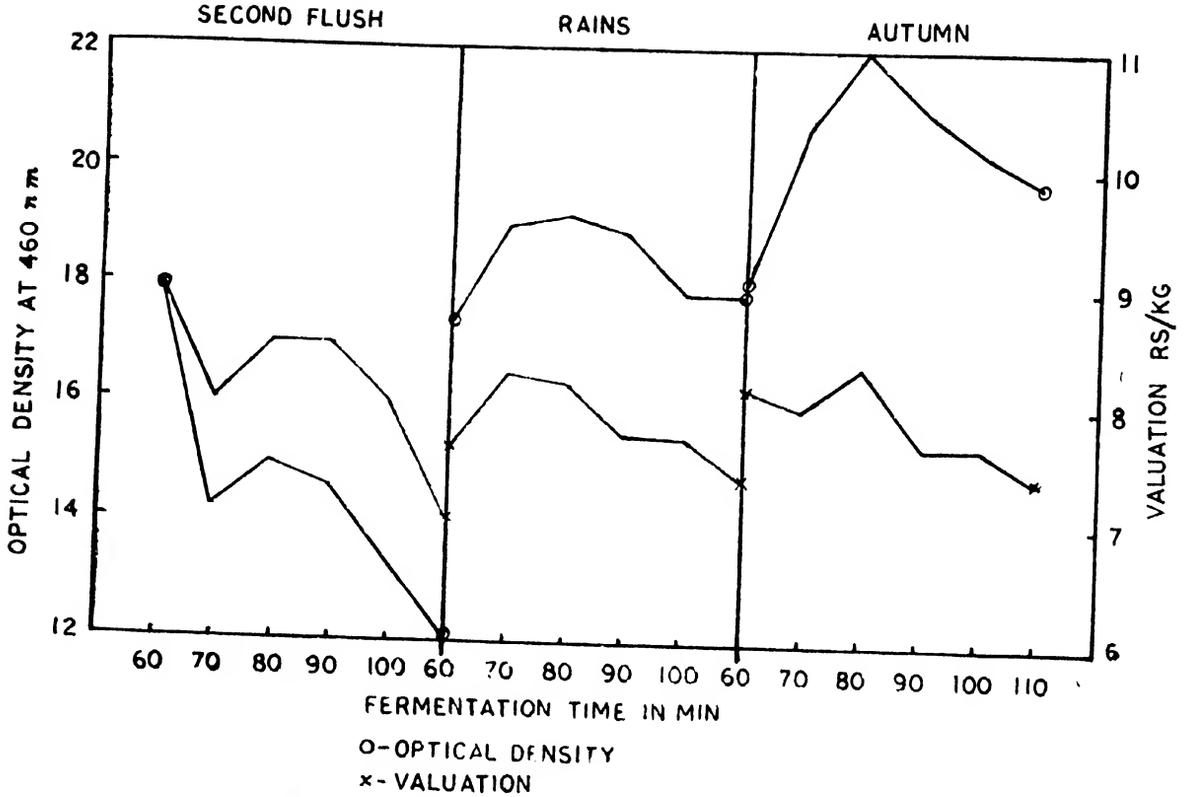


Fig. 8.5. Optical Density at 460 nm for fermented leaves of clone TV 2 during second flush, rains and autumn and corresponding Tasters' valuations of the made teas

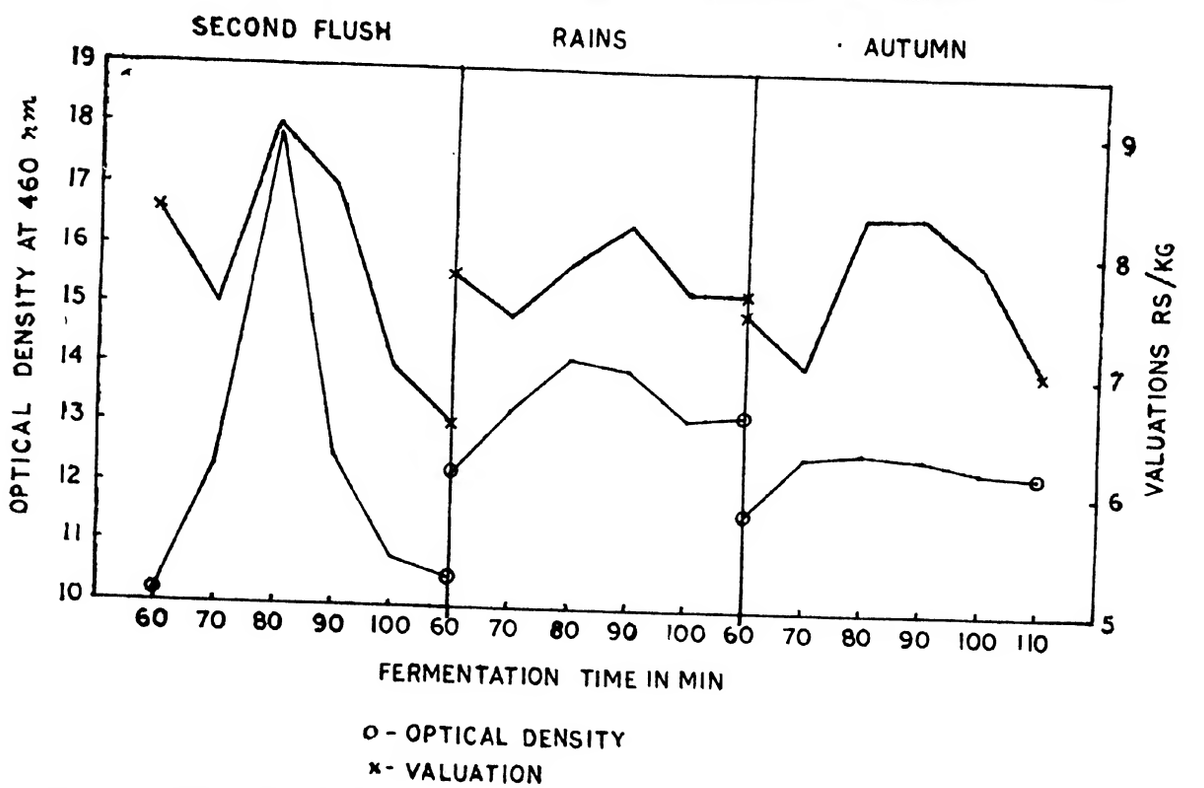


Fig. 8.6. Optical Density at 460 nm for fermented leaves of clone TV 18 during second flush, rains and autumn and corresponding Tasters' valuations of the made teas

Highest O.D. did not always correspond to highest valuation. This could be attributed to a number of factors. Tea tasters from different areas vary in their preferences. Attainment of the highest TF value by a mass of fermenting leaf may not always be supplemented by an adequate amount of TR to give the requisite body to the infusion, for which extension of the fermentation time beyond the point that gives the highest O.D. of TF, might be necessary. Drying of the fermented leaf also can play an important role on the quality of the tea which is not accounted for while testing the fermented leaf. Nevertheless, the figures indicate that the test can serve as an useful tool in assessing the progress of fermentation. However, further experimentation on large scale manufacture would be necessary for deciding on its applicability to commercial tea factories.

Routine chemical analysis of samples

Two hundred six samples from various departments of the Station and 198 samples from Tea Estates were analysed for theaflavins, thearubigins and moisture content during the year. A number of samples were also analysed for caffeine content. This includes a few of the samples received from the Central Excise and the Defence departments.

From samples of water received, Tea Estates were advised on their suitability for use in tea factories.

Moisture meters

A number of Kaybee and N-Foss Moisture Meters received from different Tea Estates were calibrated in the department.

General

Mr. M. N. Dev Choudhury was away from the Station from April '76 to November '76 on deputation to Punjab Agricultural University, Ludhiana, to work for the Ph. D. degree on amino acids, sugars and chlorophylls of tea.

Dr. M. R. Ullah was deputed to Indian Institute of Science, Bangalore, from end August to mid December '76 to work on the carotenoids of tea.

No alternatives to conventional lining for packing tea, were still found satisfactory. For good tip colour, optimum period of trough withering varies from clone to clone. For more broken grades in CTC, employment of 8, 10, 8 groove for 1st, 2nd and 3rd cuts, was advantageous. More extraction of fines in dual manufacture adversely affected CTC quality. Blending of jat tea with certain clones gave an appreciable boost to rain quality.

The main activity of this department centres around assistance to planters for maintenance and improvement of tea quality. For achieving this objective it uses organoleptic tests to evaluate planting material and agrotechniques, assesses the impact of methods of manufacture on grades and quality of made tea, studies various packing materials in their efficacy to keep the teas taint and moisture free and tests detergents, paints and conveyor belts to identify those which do not adversely affect the quality of the final product. In this context it liaises closely with other research departments at Tocklai and its outstations and conducts visits to factories and organises tasting sessions for the planter members. The department has full fledged mini-manufacture facilities at Tocklai and Nagrakata : the miniature manufacture factory at Nagrakata was established in 1971-72 as a measure of quality control in the Dooars. The two tea tasters are located at Tocklai and Nagrakata. The activities of the department during the year 1976-77 are given below :

Packaging and Storage

In order to reduce the cost of packaging and storage a few non-conventional types of paper materials and cellulose films for lining have been tried as alternatives to normal packaging material and lining.

Paper material for lining : (1) Minkote (Poly/urethene coated paper), (2) Cellophane, (3) Multiwall paper bag.

Minkote from Tea-Ma Consortium Ltd. and Cellophane from Jorehaut Tea Company Ltd., were tested for their suitability as alternative lining materials to metallic foil. From the tests it was found that these materials did not impart any taint to made teas. But a number of trials carried out could not conclusively indicate the efficacy of these lining materials as impervious to moisture above the permissible limit. Perhaps one of the major sources of error is the small size of tea chest used in these trials. It may be mentioned that in a 5 kg tea chest every kg of tea packed is exposed to 750 sq cm of lining surface and 60 sq. cm of the joint as against 296 sq cm of lining surface and 12 sq cm of the joint of the tea chest for every kilo of tea in a normal sized chest of 40 cm × 50 cm × 60 cm. Further trials with full sized chest are necessary.

As a substitute for tea chests both for internal a external markets Multiwall paper bags of the follow descriptions were received from Tea Board for pack ing of broken grades.

Paper cloth, Poly paper—two ply paper = 5]
Two ply poly paper, two ply paper = 5]
One poly paper, three ply paper = 5]

These paper bags were compared for three mont in a storage trial of tea against a control sample stor in a normally packed plywood tea chest lined wi conventional aluminium foil and with tissue pape Samples of tea were drawn every one mont The experimental storage paper bags did n taint the teas, as was evident from the reports all the panels of Tea Tasters including the Tocklai Ta ter. But the bags did not provide barrier against moi ture as efficiently as the control package as is clear fro table 9.1

Table 9.1. *Moisture Content (%) of tea stored in Multiwall Paper bags monthly intervals (initial moisture content =4.5%)*

Paking	22/7/76 1 month	22/8/76 2 months	22/9/76 3 months
A	7.75	8.05	8.56
B	9.00	9.35	9.65
C	7.34	8.30	9.31
D	5.25	5.43	5.60

A = Paper cloth, Poly paper -two ply paper = 5 ply
B = Two ply poly paper, two ply paper = 5 ply
C = One poly paper, three ply paper = 5 ply
D = Conventional lining with aluminium foil and tissue paper.

As it appears, it would not be a sound proposition to pack teas in these bags as they cannot sufficiently prevent absorption of moisture during storage. Multiwall paper bag seemed to have certain distinctive demerits also and these are commented upon hereunder:

(a) The paper bag is complicated in design and make and filling of the bag is a problem as the mouth is restricted by a flap. To fill a bag takes more than half an hour which is a waste of time. The slow process of filling the bags causes longer exposure of the tea to the atmosphere and, as a result, accelerates the rate of moisture absorption.

(b) Vibratory packers cannot be used with these bags as the jerks caused by a vibratory packer can damage the bags.

(c) While stacking on the floor, the bags at the bottom suffer considerable damage.

(d) Drawing of representative samples for visual examination and organoleptic evaluation for experimental and commercial purposes poses problems due to complicated opening arrangements.

(e) Closing the bags by stapling the flap does not fully seal it.

From the experimental findings and the unsatisfactory physical properties of Multiwall paper bag it is considered that this will not be suitable even for packaging of broken grades, not to speak of dust grades.

Evaluation of commercial products

The following detergents were tested to find out their efficacies or otherwise in cleaning fermenting room floors, rolling machines etc. in tea factories.

'Amrit Pol', a liquid detergent and 'Glazy' a powdered detergent received from Messrs Amrit Lal Hari Bhai & Co., Varanasi and Agro Auto Agencies, Golaghat, Assam respectively were considered unsuitable for use due to their higher pH value beyond the acceptable limit.

Polyform waterproofing compound from Ablative Polymer Products (I) Pvt. Ltd., Calcutta were tested as a surface for fermentation of processed green leaf. For this test, a concrete slab proof and a tray coated with the above mentioned compound, were used for spreading of fermenting leaf over them. The process was repeated several times. The fermented leaf samples were then dried and the made tea tasted. From the tasting result on each occasion it was observed that the made tea samples did not acquire any taint or odour from the compounds. Hence as far as tainting is concerned this compound is considered suitable for coating fermenting surfaces. However the tests relating to physical strength and durability of the slab are outside the scope of our investigation and no comments can be made in this respect.

Assessment of Clones

(a) **For Tocklai :** As in the previous years, this year also the department continued to render active support to Botany Department in selection of clones. Clonal leaf samples were manufactured in the miniature factory both in Orthodox and C.T.C. methods throughout the season. These samples were tasted by different panels of tasters including the Tocklai taster.

(b) **For Commercial planters :** Twenty four garden clones were tested for quality and suitability under Dooars conditions. Assessment is being done. No certificate could yet be issued.

Clonal green leaf was supplied by different gardens for manufacture in Nagrakata miniature factory. Some of these clones are showing encouraging results and have been selected for further trials.

Effect of Agrotechniques

(a) **Management Practices and Biochemical experiment :** A total of 501 clonal leaf samples were manufactured in the miniature factory in connection with the study of pigment profile, manuring experiment and Tocklai fermentation test. Made tea samples were also tasted and reported on for the Biochemistry Department.

(b) **Zinc Trial :** While foliar application of zinc is becoming more and more popular, it has become necessary to study the effect of zinc on quality and cup character. Some manufacturing trials were conducted but the results were inconclusive, hence further study is required. The experiment will be continued.

Effect of manufacture techniques

(a) **Withering :** A study was made in the Tocklai miniature factory to find out the effect of different periods of wither on colour of tip which is to a large extent responsible for the appearance and the market price of orthodox tea.

In this study TV1, TV2, TV11 and TV16 were selected and the duration of wither given were 3 hrs., 9 hrs., 15 hrs. and 18 hrs. for each clones. The desired wither of all these clones were obtained by using trough under controlled conditions. The percentage of wither was between 65 to 68%. Reports of different panels of tasters and the Tocklai taster varied.

TV1 gave better colour of tip at 9 hours wither, but in some cases TV2 showed better colour of tip at 15 hrs. and TV11 at 18 hrs.

The results are therefore inconclusive and the experiment will be carried out further.

(b) **Effect of grade percentage using 8 groove and 10 groove C.T.C. segments :** The experiment was initiated to find out the percentage of grades by using 8 groove and 10 groove C.T.C. segments in different cuts. A little clearance between the rollers was given in the second cut while using 10 groove segments. The object is also aimed at determining the influence on the cup character of the made teas.

This experiment was simultaneously conducted both in a commercial estate and in the Tocklai miniature factory. The results are given below in table 9.2.

Table 9.2. *Grade percentages obtained in different C.T.C. cuts*

Grades / CTC cuts	1st	2nd	3rd
	8 grooves	8 grooves	10 grooves
	8 grooves	10 grooves	8 grooves
	8 grooves	10 grooves	10 grooves
A. Tocklai Miniature Factory			
Broken	32.41 %	35.62 %	19.74 %
Fannings	50.33	47.82	57.90
Dust	16.06	15.02	21.42
Residue	1.20	1.54	0.94
B. Commercial Factory *			
Broken		35.01	17.67
Fannings		30.70	47.43
Dust		34.19	34.90
Residue		.09	00.00

* Cut 1 & 2 with 8 grooves and cut 3 with 10 grooves is not in practice in the concerned garden.

The table show that for producing more brokens it would be advantageous to use 8 groove segments for the first cut followed by 10 groove segments for the second cut and again 8 groove in the third cut.

(c) **Dual Manufacture :** In 1975 eight Tocklai released clones were manufactured in two series to study the performance of these clones under Dooars conditions for dual manufacture. The results were very encouraging. Hence four clones were selected in 1976 and manufacture was done with different percentage of extraction of fines. The clones were TV11, TV16, TV19 and TV20 and the extraction of fines was 15% and 20% for each clone. It was observed that the higher the percentage of extraction of fines from these clones the poorer the quality in CTC teas.

(d) **Blending on Rains tea quality :** A preliminary blending experiment was initiated to assess the improvement of rains tea quality by mixing of clonal and jat tea in different proportions during rains. For this experiment three popular Tocklai released clones and a jat were selected. The method of manufacture was C.T.C. and the made teas were mixed in different proportions and the liquors of the made tea blend gave encouraging results. The samples were tasted by two leading blending firms in India and the Tocklai Tasters. From this experiment it appears that inclusion of some clones even in a small quantity gives an appreciable boost to the liquor characters of the bulk of tea manufactured during rains. The experiment will be continued during the next manufacturing season.

Extension Services

(a) **Tasting Sessions :** In different areas India, 26 group tea tasting sessions, as arrange Area Scientific Committees, were held for th of the planters. This includes one group tast at Tocklai. Four group tastings were also held a mara for A.T.C.L. gardens.

The Tea Tasters visited 70 gardens for adv manufacturing problems of the respective

(b) **Seminars :** Seven Engineering & Man ing Seminars held in N.E. India were attended Tea Tasters.

(c) **Tasting :** Number of samples tasted dur year at Tocklai :

Tocklai samples ..	
Outside clonal samples ..	
Outside experimental samples	
	1

Number of samples tasted duri year at Nagrakata :

Clonal samples ..	2
Experimental samples ..	1
Garden samples ..	7
	12

Engineering Research & Development

The trial of 45 cm prototype continuous tea roller at Borbam T.E. showed very good results during the year.

A 37 cm prototype continuous tea roller was also developed during the year. After some initial troubles it showed some improvement during the later part of the season.

The commercial Disc Roller at Itakhooli T.E. showed some temporary improvements after some modifications, but could not be used regularly. The commercial prototype Disc roller at Orangajuli was found to give good results as a 3rd roll machine during the end season but used to expose too many stalks.

There has been some delay in the commercial production of the improved cutter attachment although the drawings have been finalised and approved during the year. The commercial production of the improved B.L.C. has been started during the year.

The trials of the withered leaf preconditioner showed encouraging results. Work on its further development is being done.

Some work on Time & Motion study was done in collaboration with the Agricultural Economics Department. Work is also undertaken to find an effective method separating the stalks from orthodox tea.

CONTINUOUS GREEN LEAF PROCESSING MACHINES

Continuous Tea Roller

(i) 45 cm prototype. The 45 cm prototype Continuous Tea Roller remained under trial at Borbam T.E. during the whole season and work was continued for its further development with particular attention to improve the first fines. During the early part of the season trials were made with different adjustments and combinations of vanes and battens etc., and therefore, consistant results were always not obtained during that part of the season. After these trials, the best setting and combination found that far was retained and hence during the later part of the season the machine consistently showed very good result, and the teas manufactured in this machine were valued higher than the conventional orthodox teas as can be seen from the average valuations of the first fines and the C.T.C. teas from the remaining bulk given by the Tocklai Taster shown in table 9.1. From the table it is clear that while during the later part of the season the first fines from the Continuous Tea Roller were valued reasonably higher than the conventional first fines, the C.T.C. teas from the remaining bulk from this machine were almost invariably valued higher than the corresponding conventional C.T.C. teas.

Table 9.1. *Trial of 45 cm Prototype C.T.R. Monthly average Valuations in R./kg given by Tocklai Taster.*

Month	1st fine		C. T. C.	
	C.T.R.	Conventional	C.T.R.	Conventional
April	10.00	10.67	—	—
May	7.61	7.68	—	—
June	7.07	7.27	8.30	7.50
July	8.19	8.25	8.71	8.32
August	8.41	8.38	7.82	8.50
September	8.42	8.23	8.38	8.25
October	9.29	9.00	8.54	8.46
November	9.28	9.22	9.73	9.77

Samples were sent to commercial Tea Tasters. Unfortunately tasting reports were not received regularly after August and therefore the average valuation calculated from the few reports received for October do not really give a true picture. These are shown in table 9.2.

Table 9.2. *Trial of 45 cm C.T.R : Monthly average valuations in Rs/kg given by commercial Tea Taster.*

Month	1st fine		C. T. C.	
	C.T.R.	Conventional	C.T.R.	Conventional
April	—	—	—	—
May	—	—	—	—
June	16.72	15.48	13.87	12.12
July	12.31	12.75	11.90	11.84
August	10.74	10.74	11.37	11.33
September	—	—	—	—
*October	14.68	17.20	10.68	10.84
November	—	—	—	—

*Based on a few reports only.

A few trials were also conducted to find out the percentage of different grades obtained from the Continuous Tea Roller both in case of 100% orthodox manufacture as well as dual manufacture. The comparative grade percentages against conventional values of Borbam T.E. are given in table 9.3. The comparative valuations of these samples are given in table 9.4.

(ii) 37 cm prototype. Trials were also initiated with the smaller, 37 cm prototype continuous tea roller, built last year and installed in tandem with the 45 cm prototype at Borbam T.E. early this year. Although this machine was simillar to the 45 cm machine, because of the scale effect the initial performance was not of the standard of the 45 cm machine. Hence work on its further development was taken up and the machine was tried out with different modifications. These included change of the dimensions of the annular space between the cylinder and the rotor, change of the number and position of the vanes and battens etc. With these modifications the result showed some improvements no doubt, but were not consistent all through. It is expected that during

Table 9.3. *Grade percentages of C.T.R. and Conventional orthodox teas*

Date	Method of Mfr.	% Primary grades													
		TGFOP		GFOP		FBOP		GFBOP		GBOP		OF		PD/Dust	
		CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal
23.11.76	100% orthodox (3 roll)	1.88	4.45	4.66	4.16	13.22	13.30	17.79	16.32	16.83	12.15	2.98	3.02	15.24	14.02
2.12.76	100% orthodox (3 roll)	2.90	2.10	3.40	3.20	9.90	8.50	13.80	11.60	7.20	4.80	4.80	3.40	4.00	2.60
5.12.76	100% orthodox (3 roll)	1.51	0.85	1.89	1.02	4.15	2.20	8.30	2.37	7.55	2.20	1.89	1.36	8.30	4.07
18.11.76	Dual	10.91	10.81	7.82	8.92	12.73	11.89	16.73	16.49	10.91	8.10	2.90	4.05	7.09	4.60
19.11.76	Dual	7.71	6.67	4.86	4.17	22.29	25.63	19.14	20.83	15.00	13.33	7.14	6.25	6.00	5.62
26.11.76	Dual	5.80	9.20	6.50	5.20	15.50	17.20	17.70	18.00	12.50	10.40	5.50	5.60	7.60	5.20

Table 9.4. *Valuations in Rs/kg of C.T.R. and Conventional orthodox comparative grades.*

Date	Method of Mfr.	TGFOP		GFOP		FBOP		GFBOP		GBOP		OF		PD/Dust		Mean valuations for all grades Rs/kg	
		CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal	CTR	Normal
23.11.76	100% orthodox (3 roll)	6.00	7.00	6.50	7.00	6.50	7.00	6.50	7.00	7.00	6.50	6.50	7.00	—	—	6.63	6.88
18.11.76	Dual	7.00	8.00	6.00	6.50	6.00	6.50	7.00	7.50	6.00	6.50	6.00	6.50	—	—	6.44	7.04
19.11.76	Dual	6.50	7.00	6.00	7.00	7.00	6.50	7.00	6.25	7.00	7.00	6.50	7.00	7.50	7.00	6.88	6.65

Note : The tasting reports on the samples of the other dates were not received.

the next season its problems could be sorted out to bring it upto the standard. The average valuations of the teas manufactured in this prototype given by the Tocklai Taster and commercial Taster are shown in table 9.5 and 9.6.

Table 9.5. *Trial of 37 cm. prototype C. T. R. in tandem with 45 cm prototype : Monthly average valuations in Rs/kg given by Tocklai Taster*

Month	1st fine		C.T.C.	
	C.T.R.	Conventional	C. T. R.	Conventional
May	7.94	8.44	—	—
June	6.50	7.13	—	—
July	7.95	8.58	8.17	8.33
August	8.17	8.00	8.22	8.64
September	7.50	7.17	8.37	8.75
October	7.50	7.50	7.75	8.25
November	7.50	8.00	7.54	7.71

Table 9.6. *Trial of 37 cm prototype C.T.R. in tandem with 45 cm prototype : Average valuations in Rs/kg given by commercial Tea Taster.*

Date	1st fine		C. T. C.	
	C.T.R.	Conventional	C.T.R.	Conventional
21.7.76	12.50	14.00	11.00	12.00
22.7.76	14.00	14.50	11.50	12.00
24.7.76	15.00	16.00	10.20	10.50
1.8.76	10.40	9.60	11.20	11.80
11.8.76	10.40	10.20	11.00	11.20

Disc Type Continuous Roller

The Commercial unit of 122 cm (48") Disc Roller installed at Itakhooli T.E. had some troubles due to some constructional defects. Necessary suggestions have been made to the manufacturers for rectifying these defects. Some of these were accepted and temporary modifications were made. This improved the machine only temporarily and therefore the machine could not be used regularly.

The first commercial prototype 122 cm (48") Disc Roller was under trial at Orangajuli T.E. According to a report from this garden the machine "was found quite suitable for third roll purposes *only* for orthodox manufacture. The percentage of fines produced in this process was very satisfactory and there was a little more bloom in the resultant Disc Roller tea after firing". But the report adds that the roller was generating a good deal of stalk and therefore made the machine unsuitable for orthodox manufacture at its present stage of development.

Cutter Attachment for B.L.C. and Rotorvane

The drawings of the Cutter Attachment as modified at Tocklai have been finalised by the licensees and have been approved by T.R.A. But the commercial production was delayed because the licensees could not make the stainless steel castings for the blades. In the meantime it has been decided to award two more licences for the manufacture of the attachment. Quotations have so far been received from one firm.

Barbora Leaf Conditioner

The commercial unit of B.L.C. modified at Tocklai for better performance and adaptability to the Cutter

Attachment was further tried out by the licensees and the drawings were then finalised incorporating all the modifications necessary for its improved performance. After the drawings have been approved by Tocklai the commercial production has been started within the year.

Withered Leaf Preconditioner

The Withered Leaf Preconditioner was brought back from Dufflaghur T.E. and was installed at Borbam T.E. after necessary servicings at Tocklai. Withered leaf conditioned by this machine was rolled in the 45 cm. prototype Continuous Tea Roller by passing through it once only, and was compared with teas produced by conventional roller as well as by two passes through the 45 cm. C.T.R. The comparative valuations given by Tocklai Taster are recorded in table 9.7.

Table 9.7. *Trial of Withered Leaf Preconditioner : Valuations in Rs/kg by Tocklai Taster*

	1st fine			C. T. C.		
Date	Pre-condi-tioner-+ C.T.R. 1 pass	Con-ventio-nal	C.T.R. two pass	Pre-condi-tioner-+ C.T.R. 1 pass	Con-ventio-nal	C. T. R. two pass
8.9.76	9.00	7.00	8.00	—	—	—
9.9.76	8.00	8.50	8.00	7.50	9.00	—
10.9.76	7.00	8.00	—	7.50	7.50	9.00
12.9.76	7.00	8.00	9.00	7.50	8.00	7.50
15.9.76	11.00	9.00	10.00	8.00	9.00	8.50
16.9.76	9.00	9.00	8.00	9.00	8.50	8.50
18.9.76	9.00	9.00	7.50	8.00	9.00	8.50
19.9.76	8.50	9.00	9.50	9.00	7.50	8.50

This table shows that the results of this trial are encouraging. But some difficulties were faced during the trials because there is no provision for adjustment of the gap between the rollers and because the rollers which are made of wood chip off at the ridges of the helixes. Therefore the machine was brought back to Tocklai for replacement of the rollers and for making them adjustable to cope with different kinds of leaves and different degrees of wither.

TIME AND MOTION STUDY

In collaboration with the Agricultural Economics Department some work was done on Time and Motion study in the field and factory of Sycotta T.E. during the year. Data were collected in the field on plucking and in the factory on loading and unloading of withering troughs. These data were given to Agricultural Economics Department for analysis.

SEPARATION OF STALK

To explore the possibility of separating the stalks from orthodox tea by taking the advantage of the straightness of stalks in contrast to somewhat curled appearance of orthodox leaf tea, a model machine has been prepared. The separating grate designed with this principle could not work well when vibrated by a vibrator. Other methods of using this grate are being studied.

GENERAL

The Second Research Engineer continued to be in charge of the department and towards the end of the year he was designated Research Engineer and made the Departmental Head. Apart from his frequent visits to Borbam T.E. in connection with the trials of the Continuous Tea Roller and the Withered Leaf Preconditioner, he paid visits to 24 factories in connections with various engineering and manufacturing problems. He took part in eight Engineering and Manufacturing seminars held by Scientific committees of different areas. He also attended one Engineering Sub-Committee meeting held at Tocklai.

The study on crop and rainfall suggests that if rainfall deficiency is made up by irrigation during the dry cold weather period and adequate measures are taken to drain out excess rain water during heavy monsoons, annual yield of tea can be increased by about 22 per cent in Northern part of Binnaguri and by about 52 per cent in Southern part of Nagrakata sub-districts of Dooars.

Results obtained so far from the survey data on field management and environmental factors affecting the yield of tea in Darjeeling reveal that requirement and response in yield due to nitrogen depend very much on the angle of the slope, aspect, elevation, soil type of the area, length of pruning cycle and on the age of tea.

Crop-Weather Studies

The results obtained from the study on crop and rainfall data for the Southern part of Binnaguri sub-district was reported in the Annual Scientific Report 1975-76, pp. 60-61. Similar study on crop and rainfall data obtained for the period 1957 to 1972 from the estates representing the soil-climatic conditions of the Northern part of Binnaguri and Southern part of Nagrakata sub-districts of Dooars continued during the year. The objective and method of the study were the same as reported earlier.

(a) Binnaguri Sub-district (Northern Part) of Dooars

The type of relationship between annual yield of tea and different periods of rainfall in the Northern part of Binnaguri sub-district is represented by the followi equation :

$$Y = 41.3018\ R_3 + 17.3593\ R_4 - 0.3220\ R_4^2 + 160.2793\ \log_{10} R_5 + 4.0177\ R_6 - 2.2419\ R_7 + 17.5972\ R_8 - 0.1166\ R_8^2 + 27.7521\ R_9 - 0.2274\ R_9^2 - 199.4246 \quad \ldots\ldots\ldots\ldots (1)$$

where, Y = annual yield of made tea in kg/ha; R_3, R_4 R_5, R_6, R_7, R_8 and R_9 represent the rainfall in centimetre during January-March, April, May, June, July August and September respectively. Rainfall during these seven periods together contributed about 98 per cent towards the annual yield, whereas contribution due to rainfall during October (R_1) and November-December (R_2) of the previous season was not significant.

The distribution pattern of rainfall and their relationship with yield suggest that if rainall deficiencies are made up during cold weather by irrigation and excess water is drained out during heavy monsoons as shown in Table 11.1, the annual yield of tea in the Northern part of Binnaguri sub-district can be increased by 355 kilograms of made tea/ha which is about 22 per cent of the actual yield recorded.

Table 11.1. *Rainfall distribution during critical periods and the estimated irrigation requirement with the corresponding expected yield*
Region : *Northern part of Binnaguri sub-district of Dooars*

Critical period	Rainfall in centimetre			Type of relationship*	Irrigation requirement (cm)		Average yield of made tea in kg/ha		
	Minimum	Maximum	Average		Range	Average	Without irrigation	With irrigation (Estimated)	Gain due to irrigation
January									
March	1	14	7	L (+)	0—13	7			
April	1	40	14	LQ (+ –)	0—26	13			
May	16	71	33	log (+)	Uneconomic]				
June	58	139	90	L (+)	"		1643	1998	355
July	53	132	97	L (–)	Drain out excess rain water				
August	31	129	76	LQ (+ –)	"				
September	26	78	52	LQ (+ –)	"				
Total irrigation requirement				→	0—39	20			

* L = Linear, LQ = Quadratic and Log = Exponential.

(b) Nagrakata Sub-district (Southern Part) of Dooars

Examination of the data representing the soil-climatic conditions of Nagrakata sub-district showed that this sub-district could broadly be sub-divided into two parts on the basis of rainfall distribution, soil type and level of annual yield. Hence, the sub-district was broadly divided into two parts for the purpose of this study and the result obtained for the Southern part are presented here.

Equation 2 was derived from the set of data under study which depicted the critical periods, quantity of rainfall in each period and the nature of their relationship with the annual yield of tea in the Southern part of Nagrakata sub-district.

$$Y = 54.0933\ R_2 - 9.7819\ R_2^2 + 42.8056\ R_3 + 18.6086\ R_4 + 3.3769\ R_6 + 4.2612\ R_7 + 20.9697\ R_8 - 0.0813\ R_8^2 + 8.8343\ R_9 - 0.1153\ R_9^2 - 1485.4211 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where, Y = annual yield of made tea in kg/ha; R_2, R_3, R_4, R_6, R_7, R_8 and R_9 denote rainfall in centimetre during November-December of the previous season, and January-March, April, June, July, August and September of the current season respectively. Rainfall during these seven periods together contributed about 97 per cent towards the annual yield, whereas contribution due to rainfall during October (R_1) of the previous season and May (R_5) of the current season was negligible.

The distribution pattern of rainfall and their relationship with yield suggest that if rainfall deficiencies are made up during cold weather by irrigation and excess water is drained out during heavy monsoons as shown in Table 11.2, the annual yield of tea in the Southern part of Nagrakata sub-district can be increased by 573 kilograms of made tea/ha which is about 52 per cent of the actual yield recorded.

Following important points need be stressed in the interpretation and implementation of the above results.

(i) *Gain in yield due to irrigation would mainly depend on the period of irrigation, quantity of water applied in each period and draining out the excess rain water during the critical monsoon periods as shown in Tables 11.1 and 11.2.*

Table 11.2. *Rainfall distribution during critical periods and the estimated irrigation requirement with the corresponding expected yield*
Region : *Southern part of Nagrakata sub-district of Dooars*

Critical period	Rainfall in centimetre			Type of relationship*	Irrigation requirement (cm)		Average yield of made tea in kg/ha		
	Minimum	Maximum	Average		Range	Average	Without irrigation	With irrigation (Estimated)	Gain due to irrigation
November to December (Previous season)	0	9	3	LQ (+—)	Not required]				
January to March (Current season)	2	15	8	L (+)	0—13	7			
April (,, ,,)	0	30	15	L (+)	0—30	15	1103	1676	573
June (,, ,,)	65	168	103	L (+)	Uneconomic]				
July (,, ,,)	62	182	112	L (+)	,,				
August (,, ,,)	48	190	87	LQ(+—)	,,				
September (,, ,,)	26	101	62	LQ(+—)	Drain out excess rain water				
Total irrigation requirement				→	0—43	22			

* L = Linear and LQ = Quadratic.

(ii) *The results presented here are related to the average soil-climatic conditions for the Northern part of Binnaguri and Southern part of Nagrakata sub-districts of the Dooars. Therefore, if irrigation is proposed for any individual estate, it should be based on by a careful examination of such factors as distribution of rainfall, soil type, depth of soil, etc., of the concerned estate.*

(iii) *Irrigation and drainage requirements suggested in Tables* 11.1 *and* 11.2 *need to be tested by actual field experiments before large scale programme is adopted.*

Survey on Field Management and Environmental Factors Affecting the Yield of Tea

Darjeeling, West Bengal : The object of this survey is to isolate the field management and environmental factors from long-term member estates' records which affect the yield of tea and to estimate their individual relative contributions to throw light on the future advice and course of research for increasing the yield of tea in Darjeeling and ultimately to build up models for different environmental conditions to predict the optimum input requirements for maximising the yield of tea crop.

Some of the results obtained from this study were reported in the Annual Scientific Report for 1975-76, pp. 61-62 and further results obtained during the period are reported below :

(a) **Slope × Nitrogen :** In order to find out the effect of Nitrogen on the yield of tea at different slopes of the section, the sections were broadly divided into two groups, viz., area of the sections having slope below 30° (Gentle Slope) and above 30° (Steep Slope).

It was observed that response in yield from mature tea (above 7 years old) due to unit kilogram of Nitrogen depended very much on the slope of the section. At all the levels of Nitrogen upto the observed maximum of 150 kg N/ha, responses per unit kilogram of Nitrogen were almost double in areas having gentle slope compared to those of the steeper slope. Further, areas having gentle slope responded to Nitrogen considerably upto 120 kg of Nitrogen per hectare, whereas the areas having steep slope, the response was negligible beyond 90 kg N/ha.

This result suggests that greater the angle of the slope of the area, availability of Nitrogen to the plant is not uniform and the reason for this might be due to washing of Nitrogen down the slope and also there may be some other reasons. This result also suggests that areas having gentle slope (below 30°), application of Nitrogen upto 120 kg/ha will be profitable, whereas areas having steep slope (above 30°) it is not likely to be profitable beyond 90 kg/ha.

(b) **Age × Slope × Nitrogen :** The response due to Nitrogen was found to vary between slopes within an age group and also amongst age groups within a slope. For 3 –≤ 7 years old tea, response due to Nitrogen was found to be considerable upto the observed maximum of 90 kg N/ha on gentle slope and on steep slope it was upto 60 kg N/ha. Tea of 7–≤15 years old responded quite well to Nitrogen upto the observed maximum of 120 and 60 kg N/ha on gentle and steep slopes respectively. Further, it was found that for above 15 years old tea, on gentle slope, the response in yield due to Nitrogen, in general, was considerable upto 120 kg N/ha, while on steep slope it was upto 90 kg N/ha. However, the return in yield from unit kilogram of Nitrogen was always higher on gentle slope than the steep for all ages of tea and it decreased with the increase in age.

These results, therefore, indicate that the response in yield due to Nitrogen depends very much on the angle of the slope of the area as well as on the age of tea.

(c) **Aspect × Nitrogen × Age :** Effect of Aspect × Nitrogen × Age on the yield of made tea/ha for above 60 years old tea was reported in the Annual Scientific Report, 1975-76, p. 62. Here the effect of these factors for other age groups is reported.

(i) **7 –≤15 years old tea :** At this age group sufficient data were not available for different aspects for analysis. However, some data were available for North, South and West aspects. The results suggest that on North and South aspects, application of Nitrogen beyond 60 (45 – ≤75) kg/ha may be profitable and on West aspect it is likely to be profitable upto 60 kg/ha, but beyond that it will not be profitable.

(ii) **15 –≤25 years old tea:** Analysis of the data were carried out for North, East, South-east, South and West aspects, because some data were available for these aspects only, whereas for other aspects, there was practically no data for this age group.

The results indicate that on North, South-east and West aspects, application of Nitrogen upto 90 kg/ha is likely to be profitable, whereas on East and South aspects, it may be profitable even beyond 90 kg/ha.

(iii) **25–≤40 years old tea:** For this age group data were available for analysis for five aspects only, i.e., North, East, South-east, South and South-west aspects and the maximum Nitrogen applied was 60 (mid value of 45 –≤75) kg/ha except on South aspect, where the maximum was 120 (mid value of 105 –≤135) kg/ha. On all these aspects, the return in yield from unit kilogram of Nitrogen at 60 kg/ha was considerable, but it was found to vary from aspect to aspect.

The results indicate that on North, East and South-east aspects, application of Nitrogen beyond 60 kg/ha is likely to be profitable; while on South aspect it may be profitable upto the observed maximum of 120 kg/ha.

(iv) **40 –≤60 years old tea:** The findings suggest that when the tea bushes are 40 –≤60 years old, on East, South and South-east aspects, application of Nitrogen upto 90 (mid value of 75 –≤105) kg/ha may be profitable, whereas on other aspects, i.e., North, North-east, South-west, West and North-west aspects, application of Nitrogen beyond 60 kg/ha may not be profitable.

(d) **Elevation × Nitrogen × Age:** Effect of Elevation × Nitrogen × Age on the yield of made tea/ha for above 60 years old tea was reported earlier (Annual Scientific Report, 1975-76, p. 62). Here the effect of these factors for other age groups is reported.

Response in yield due to Nitrogen varied from elevation to elevation within an age group and also within an elevation amongst age groups. It was also found that higher the elevation lower was the return in yield from unit kilogram of Nitrogen at all levels of Nitrogen and age groups.

For each age group results are summarised below.

(i) **7 –≤15 years old tea :** At elevation upto 305 m (upto 1000′) increase in yield/ha due to Nitrogen was directly proportional to the increase in level of Nitrogen upto the observed maximum of 120 (mid value of 105 –≤135) kg/ha. At elevation 305–≤1220 m(1000′ —≤4000′), Nitrogen was applied only upto 60 (mid value of 45 –≤75) kg/ha and upto this level return in yield from unit kilogram of Nitrogen was found to be considerable. At elevation 1220 –≤1525 m (4000′—≤5000′), yield increased upto the observed maximum of 90 (mid value of 75 –≤105) kilograms of Nitrogen/ha, but the return in yield from unit kilogram of Nitrogen decreased considerably at 90 kg/ha.

These results suggest that at elevation upto 305 m, application of Nitrogen upto the observed maximum of 120 kg/ha will be profitable. Further, at elevation 305 —≤915 m, application of Nitrogen beyond 60 kg/ha may be profitable, whereas at elevation 915 —≤1525 m it may not be profitable beyond 60 kg/ha.

(ii) **15–≤25 years old tea :** For this age group, the results indicate that at elevation upto 305 m, application of Nitrogen beyond 120 (mid value of 105 –≤135) kg/ha may be profitable, whereas at elevation 305 —≤1525 m it is likely to be profitable upto the observed maximum of 90 (mid value of 75 — 105) kg/ha.

(iii) **25 $\leqslant$ 40 years old tea:** The results for this age group suggest that at elevation upto 305 m, application of Nitrogen beyond 120 (mid value of 105 $-\leqslant$ 135) kg/ha will be profitable. Whereas, at elevations 305—$\leqslant$610 m and 610—$\leqslant$915 m, it will be profitable upto the observed maximum of 120 (mid value of 105 —$\geqslant$135) and 90 (mid value of 75 —$\leqslant$105) kg/ha respectively. On the other hand, at elevation 915—$\geqslant$1525 m, it may not be profitable beyond 60 (mid value of 45—$\geqslant$75) kg/ha.

(iv) **40 $\leqslant$ 60 years old tea:** The maximum of 120 (mid value of 105 —$\leqslant$135) kilograms of Nitrogen per hectare were applied at elevation upto 1220 m and at elevation 1220—$\leqslant$1525 m, it was 90 (mid value of 75— $\leqslant$105) kg/ha.

The findings suggest that at elevation upto 305 m, application of Nitrogen upto the observed maximum of 120 kg/ha will be profitable, while at elevation 305 —$\leqslant$1220 m and 1220 —$\leqslant$1830 m, it may not be profitable beyond 90 and 60 kg/ha respectively.

(e) **Age $\times$ Soil Type :** In order to study the effect of age on the yielding capacity of tea bushes under different soil types, sections of all the tea estates in Darjeeling were broadly divided into two soil types, i.e., Light and Heavy soils. Yield per hectare harvested from tea bushes planted on both the soil types was found to rise steadily with the increase in age upto about 35 years. Beyond that age, yield of tea planted on Heavy soil decreased rapidly upto about 55 years and thereafter it became more or less steady, whereas tea planted on Light soil the decrease was rapid upto about 70 years old and then it was more or less steady. Though the decreasing trend in yield on Light soil lasted longer than that on Heavy soil, but tea planted on Light soil gave higher yield per hectare at all ages as compared to that of tea planted on Heavy soil.

(f) **Age $\times$ Soil Type $\times$ Nitrogen :** On Light type of soil, maximum application of Nitrogen was found to be 120 kg/ha at all ages above 7 years old tea, whereas on Heavy soil it was 90 kg/ha or below. It was interesting to note that on Light soil, response in yield due to Nitrogen from 7 to 60 years old tea was considerable upto the observed maximum of 120 kg/ha whereas, above 60 years old tea gave poor response at this level. Further, above 7 years old tea planted on Heavy soil responded well to Nitrogen upto the observed maximum of 90 kg/ha or below. But, the return from unit kilogram of Nitrogen gradually decreased with the increase in Nitrogen level and also with the increase in age on both the soil types. From the results it was clear that in general, at all ages and levels of Nitrogen, tea planted on Light soil gave more return from unit kilogram of Nitrogen than that planted on Heavy soil.

These results, therefore, indicate that when the tea bushes are planted on Light soil and the age of the bushes are between 7 to 25 years, application of Nitrogen above 120 kg/ha and when the bushes are between 25 to 60 years old, application upto 120 kg/ha (mid value of 105 —$\leqslant$135 kg/ha) is likely to be profitable. But when the bushes are above 60 years old, application beyond 90 kg/ha (mid value of 75 —$\leqslant$105) may not be profitable. On the other hand, when the tea bushes are on Heavy soil, at all ages of tea above 7 years old, application of Nitrogen upto 90 kg/ha may be profitable.

(g) **Pruning Cycle $\times$ Nitrogen :** It is interesting to note that for above 7 years old tea, 3-year Pruning Cycle gave highest yield/ha and the lowest yield/ha was obtained from 7 year and above 7-year Pruning Cycles. Further, the response in yield due to Nitrogen was also found to vary with the length of the Pruning Cycle. The yield/ha from 2, 3, 4 and 5-year Pruning Cycles increased with the increase in Nitrogen level upto the observed maximum of 120 kg/ha. Also, the return in yield from unit kilogram of Nitrogen was considerable upto the observed maximum on 120 kg/ha for these cycles except for 5-year Cycle where it was negligible beyond 90 kg/ha. Maximum return from unit kilogram of Nitrogen was obtained from 3-year Pruning Cycle at all the observed levels of Nitrogen, i.e., upto 120 kg/ha, followed by 4-year and 2-year Pruning Cycles. Whereas, for above 5-year Pruning Cycle, response due to Nitrogen beyond 60 kg/ha was negligible.

These results, therefore, clearly suggest that averaged over all elevations and aspects, in order to obtain the maximum yield/ha, 3-year Pruning Cycle should be adopted. These results also suggest that considerable return in yield from unit kilogram of Nitrogen may be obtained from 2, 3 and 4-year Pruning Cycles beyond 120 kg/ha.

Help to Other Departments

The Department continued to extend co-operation and help in solving statistical problems encountered by research workers of practically all the Departments of the Station. Field and laboratory experimental records for 1976 on computerised proforma poured in practically from all the research departments and from the tea estates of North East India. During the year experimental records of 309 experiments for the years 1974-1976 were punched, varified and updated. Eighty one analyses of the experiments conducted during the period 1971 to 1976 were undertaken and computations of these were carried out on the Unit Record Machines at Tocklai. In addition, preliminary computations of Darjeeling Yield Survey data and calculation of accounting jobs were also carried out on these machines during the year.

One hundred ninety six analyses of the response surface data from NPK experiments conducted in different soil-climatic regions of North East India, corresponding soil test crop correlation for 1974, 1975 and 1976, and data from Systematic Fan Design experiment on spacing are in progress. Several programmes were written in FORTRAN IV language for carrying out computations of these experiments on the IBM 370 electronic computer at I.I.T., Madras and the statistical interpretation of these results are also in progress.

A number of experiments were planned and designed during the year, besides offering advice to a number of students and research workers from Assam Agricultural University on design and analysis of experiments.

Agricultural Economics

Benefit Evaluation of longer pruning cycle has shown that longer pruning cycle increases revenue through higher yield and more early crop. This benefit of longer pruning cycle over annual prune ranges from Rs. 310 per hectare to Rs. 1172 per hectare in Assam Valley, Rs. 130 per hectare to Rs. 1700 per hectare in Cachar and Rs. 372 per hectare to Rs. 1472 per hectare in Dooars. Similarly prophylactic spray against red spider infestation shows a net gain of Rs. 1139 per hectare.

Computations of fixed and variable costs showed that seven gardens in Assam Valley who responded to a questionnaire had the Break Even Yield of 978 Kg./Ha. Preliminary studies on Motion and Time Studies have indicated significant possibilities of increasing labour productivity of plucking, loading and unloading operations.

1. Benefit Evaluation of Tocklai Recommendations

The department completed two benefit evaluations of Tocklai recommendations during the year.

1. Adoption of longer pruning cycle.
2. Control against Red Spider.

(a) Economic Evaluation : longer pruning cycle

Cost benefit evaluation of longer pruning cycle was undertaken in collaboration with the Advisory Department. The object of the study was to evaluate the benefit arising from longer pruning cycle over annual prune in Tea districts of N.E. India, other than – Darjeeling.

Experimental Data-Yields recorded in Estate experiments conducted by Advisory Department, in different areas of the region during the period 1968 to 1972 were subjected to economic analysis and the results are given in Table 12.1.

Table 12.1. *Mean Yield under different pruning cycle and percent increase over annual prune.*

Cycle (Treatment)	Mean Yield of Made tea (kg/Ha) under pruning cycles: Annual Prune (Control)	Longer Cycle	Per cent increase
Assam Valley			
Prune – Deep Skiff	1916	2039	6.41
Prune — Light Skiff	1384	1516	9.53
Prune — Light Skiff– Deep Skiff	1384	1539	11.19
Prune – Prune –Light Skiff	1384	1494	7.94
Cachar			
Prune — Deep Skiff	1418	1470	3.66
Prune — Light Skiff	1453	1664	14.52
Prune — Medium Skiff	1670	1925	13.47
Prune — Medium Skiff—Light Skiff	1698	1970	16.01
Prune — Light Skiff– Medium Skiff	1698	1908	12.36
Prune — Deep Skiff —Medium Skiff	1698	1983	16.78
Prune – – Medium Skiff– Deep Skiff	1698	1894	11.54
Prune — Deep Skiff – Medium Skiff – Level off Skiff	1311	1420	8.31
Prune — Medium Skiff – Level off Skiff– Level off Skiff	1311	1467	11.89
Prune — Level off Skiff– Level off Akiff – Level off Skiff	1311	1651	25.93
Prune — Unprune – Unprune — Unprune	1311	1626	24.02
Dooars			
Prune — Deep Skiff	1477	1702	15.23
Prune — Light Skiff	1477	1702	15.23
Prune — Medium Skiff	1477	1648	11.57

Economic Benefit : Economic gains of longer pruning cycle over annual prune are reflected in three forms :

(i) Increased Annual Crop.
(ii) Higher Early Crop.
(iii) More Production of 2nd Flush Crop.

The benefits derived from three distinct factors are given below :

Factor	Benefits	Remarks
More Total Crop	Increased Revenue	There may be at drop in quality in varying degrees, and consequently of sale price, of unprune, light skiff and medium skiff tea, but the over all net gain here also will be significantly high.
Larger Early Crop (Realisation of Sale Price earlier)	Saving in Interest	
Higher Second-Flush Crop	Higher Unit Value	

The increase in annual crop adds to the revenue. The benefit is the contribution which is the difference between the sale price and the variable costs in growing, manufacturing and marketing of tea. Benefit from crop increase is given under Table 12.2.

Table 12.2. *Benefit from Crop Increase under longer pruning cycles with contribution varying between Rs. 2/- to Rs. 5/- per kg of made tea.*

Cycle	Difference in Yield Kg./Ha.	Average Contribution @ Rs. 4.89	Contribution for Marginal return on pruning of made tea/Ha. @ Rs. 2/-	@ Rs. 5/-
Assam-Valley				
P– DS	123	601	246	615
P – LS	132	645	264	660
P– LS– DS	155	758	310	775
P– P– – LS	110	538	220	550
Cachar				
P – DS	52	254	104	260
P –LS	211	1032	422	1055
P– MS	255	1247	510	1275
P – MS – LS	272	1330	544	1360
P– LS– MS	210	1027	420	1050
P—DS—MS	285	1394	570	1425
P – MS– DS	196	958	392	980
P– DS—MS – LVS	109	523	218	545
P –MS –LVS – LVS	156	763	312	780
P– LVS— LVS – LVS	340	1663	680	1700
P– UP—UP UP	315	1540	630	1575
Dooars				
P—DS	225	1100	450	1125
P– LS	225	1100	450	1125
P—MS	171	836	342	855

*Average contribution calculated from 30 gardens of North East India.

Higher Unit Value : The higher unit value of tea sold in Calcutta Auction Market for the period 1971 to 1973 only was taken into account and benefit was calculated for different regions under different pruning cycles. The benefit calculated was Rs. 526 per ha in Assam Valley, Rs. 289 per ha in Cachar and Rs. 352 per ha. in Dooars.

Interest Saving : The larger early crop helps in realising the sale price from the extra crop at least two months earlier. A saving of two months interest at 12% per

annum was calculated for different regions under pruning cycles and the benefits range between Rs. 17/- per ha to Rs. 52/- per ha.

The overall benefit taking all the three heads together was found ranging between Rs. 310/- per ha to Rs. 1172/- per ha at different levels of marginal return in Assam Valley, Rs. 130/- per ha to Rs. 1700/- per ha in Cachar and Rs. 373/- per ha to Rs. 1472/- ha in Dooars.

2. **Economic Evaluation Control against Red Spider** : Red Spider Mite is a wide spread pest of tea in North East India. More tea is lost due to the attack of red spider than any other pest. According to estimates at least half the area under tea is infested by red spider in different degrees.

Experimental Data : In the Annual Report of the Entomology Department 1974-75 (P. 35) the results of a direct estimation of the potential yield loss due to red spider and the effect of prophylactic spraying on yield were reported. A plot of 150 bushes was selected and spraying was done in May, '74 with Kelthane 18.5 E.C. at 0.23% concentration. Another plot of similar size was kept unsprayed as a control plot. After one week of spraying, the data from two plots, one sprayed and the other unsprayed, were recorded weekly till the end of Oct.'74. The results show a cumulative gain of 14% in the crop at the end of the observation period. The observations were taken for a fixed period to get a preliminary idea of probable benefit. The data are given under Table 12.3. In a study reported *in Tea and A Bud*, March, 69 issue the cumulative gain was found 25%. The present study shows a gain of 14%

Table 12.3. *Yield of Made tea from Kelthane treated and untreated plots Kg/Ha and gain in yield Kg/ha*

Period	Cumulative yield Kelthane treated plot	Control plot	Cumulative Gain in Yield
May	111	86	55
June	336	273	63
July	639	552	87
August	880	724	156
September	1104	966	138
October	1283	1104	179

Crop gain during the period 179 : 1283 × 100 = 14.00%.

Economic Benefit : The economic benefit is the gain in yield from the treated plot over that of untreated plot. The net benefit will be extra crop deducting the cost of material and labour used in the treatment. For the present calculation, the normal actual yield is taken at 1300 kg/ha. The gain in yield at 14% would equal to 182 kg/ha by prophylactic treatment. The actual crop saved would depend on the actual average yield in each section of each estate. 1300 kg/ha is taken as the average yield of tea in 1975 of N.E. India.

Spraying Expenses : Normally the prophylactic treatment is required only once in a year at the beginning of the season. The following expenses relate to one hectare of about 4600 bushes and one application. The spraying expenses consist of the wages for spraying labourer and helper for one day (2 mandays), 1¼ litres of Tedion, 3 litres petrol for running 1 spraying machine for one day and the depreciation of sprayers. To cover the cost of buying and storing, 28% is added to the cost of materials; fringe benefits at 94% of daily labour wages of Rs. 4/- is included in the cost; and an overhead at 130% on labour wages is also included. The total cost of Rs. 134.88 (or say 135/-) per hectare of 4600 bushes is detailed under table 12.4.

Table 12.4. *Cost of Spraying per Hectare (4600 bushes).*

	Item	Quantity	Rate	Amount Rs.
1.	Labour	2. Mandays	Rs. 4/- plus 91%	15.52
2.	Tedion	1.25 litres	Rs. 50/- plus 28%	80.00
3.	Petrol for driving sprayers	3 litres	Rs. 3.50 plus 28%	13.44
4.	Depareciation of sprayer	2 machine days	Rs. 4/- plus 28%	5.12
5.	Overhead on labour charges	Rs. 16/-	130%	20.80
				134.88
				or say Rs. 135/-

Benefit Calculation

For the present exercise an average selling price of Rs. 11/- per kg, and a variable cost of Rs. 4/- per kg are adopted. The main saving is in the extra tea produced, which as seen earlier is 14% of the average production per hectare. The savings in terms of money would be "Contribution" made by the production saved. Since the fixed expenses per hectare remain unaltered; the contribution equals the sale price of the tea reduced by the variable expenses such as plucking, manufacturing, packing case, exercise duty, selling and freight expenses, the latter totalling Rs. 4/- per kg with a sale price of Rs. 11/- per kg, the contribution is Rs. 7/- per kg. The computations are summarised below :

Benefit of prophylactic spray against red spider per Hectare

1.	Extra tea made per hectare	182 kg
2.	Saving at Rs. 7/- per kg. (Sale price Rs. 11 - Rs. 4/- variable Cost)	Rs. 1274.00
3.	Deduct Expenses	Rs. 135.00
		Rs. 1139.00

The margin of saving shows a substantial benefit of Rs. 1139/- per hectare per year without taking into account the interest accrual on this amount which would add another Rs. 64/- at 10% per annum.

While the quantities will not vary much, expenses and benefits will vary from time to time depending upon the price prevailing at the time of observation. The expenses may vary within a range, but the figures used are averages of expected expenditure. This will not materially affect the conclusion drawn.

Benefits to the Industry : Red spider attack is estimated to cover atleast half of the area under tea with varying degree of infestation. The area under tea in North East India is approximately 2,75,630 ha. If the whole area has to be prophylactically sprayed in order to save the crop, this would cost the industry a sum of Rs. 37 millions at Rs. 135/- per ha. But the benefit that can be expected at half of the above maximum of 14% of normal production i.e. 7% of 383 million kg would be 26.81 million kg of tea which at Rs. 7 per kg could give a net benefit to the industry a sum of Rs. 188 millions.

3. **Break Even Yield in relation to cost components :** During the year under review, studies had been undertaken on the impact of various components on the level of yield below which a section becomes unprofitable. Before the data is presented, it is worthwhile to present some definitions and concepts.

Fixed and Variable Cost : Fixed and variable costs are the results of the analysis in a particular manner of result oriented expenses.

(a) Fixed expenses remain significantly unchanged even though the result, product or benefit, changes significantly but within certain limits.

(b) Semi-fixed expenses remain fixed within certain limits but changes at each step of the limit, but not proportionate to the result, product or benefit.

(c) Variable expenses change significantly in the ratio of the result, product or benefit.

The total expenses of an activity can be broadly divided into fixed and variable with reference to the relation with the result or product.

Total Expenses = Fixed + Variable

If Q is the quantity of the product

$$\text{Unit Cost } C = \frac{\text{Total Expenses}}{Q} = \frac{\text{Fixed Expense}}{Q} + \frac{\text{Variable Expenses}}{Q}$$

Using Symbols

$$C = \frac{T}{Q} = \frac{F}{Q} + \frac{V}{Q}$$

Since variable expenses vary significantly with production it would mean

$$\frac{V}{Q} = \frac{V_1}{Q_1} = \frac{V_2}{Q_2} = K \text{ say}$$

But since F remains significantly unchanged when Q varies, the fixed cost per unit of production.

$\frac{F}{Q}, \frac{F}{Q_1}, \frac{F}{Q_2}$ etc. will be different at different levels of yield. Thus, to restate :

(i) Variable expenses vary with volume of production, but the variable unit cost tends to be fixed (or constant).

(ii) Fixed expenses remain constant (or fixed) but the fixed unit cost tends to vary.

Break Even Concept in Tea Plantation : Break Even Concept is basically concerned with finding the point at which revenue equals cost. At this point, called Break Even Point (BEP), the value of input factors are equal to the output. It is a convenient tool in meauring the effectiveness of planning and control viz-a-viz with what others are doing, with respect to individual segments of an enterprise and also the enterprise as a whole.

The Break-even fourmulae are:

$$(1)\quad BEP = \frac{F}{1 - \frac{V}{S}}$$

$$(2)\quad BEP = \frac{F}{S - V}$$

F —Fixed Cost.
V —Variable Cost.
S —Sale Price.

The profit is made only by the units above the BEP and if production falls short of the level of BEP, loss accrues. By knowing the number of units made and sold above or below BEP the quantum of profit or loss made can be ascertained.

Break Even Yield

The above general concept can be applied to a variety of circumstances in Tea Plantation Industry. One specific application was shown in an article published in "Two And A Bud" (Vol. 2, Dec., '76), to determine the Break Even Yield (BEY) of an estate or any section of an estate.

Break Even Yield may be defined as that yield per hectare of the estate or a section of the estate, at which no profit or loss is made. Having determined the BEY it is a simple matter to ascertain the profitability or otherwise of an estate, or a section, by comparing the actual yield with the BEY.

The department collected data about fixed and variable expenses, average sale price and saleable tea made from 26 gardens of the plains of N.E. India for the year 1975 with the Rejuvenation questionnaire. The data showed considerable divergences in the quantum of fixed expenses as a ratio of total cost. After detailed scrutiny it was found that only 7 replies could be used for further study, 2 from North Bank an 5 from South Bank of Assam Valley.

Computation of BEY of 7 Gardens of Assam Valley

Average Yield = 1524 kg/ha
Sale Price = Rs. 11.32 per kg
Fixed Cost = Rs. 4.89 per kg
Variable Cost = Rs. 3.70 per kg

$$BEY = \frac{\text{Fixed Expenses per ha}}{\text{(Sale Price Per kg. Variable Cost)}} = \frac{F}{(S \quad V)}$$

$$= \frac{1524 \times 4.89}{(11.32 \quad 3.70)} = 978 \text{ kg}$$

One of the most important uses of BEY is to judge the economic viability and profitability of the estate as a whole or of any section.

4. **Motion & Time Study :** During May to July, 1976, the department undertook a pilot study on Motion & Time Study in the field and factory of two nearby estates. Plucking, loading green leaf into withering trough and unloading the withered leaf from withering troughs were studied to a limited extent.

(a) **Plucking** : In case of plucking it was found that 2 hours 50 minutes were wasted or spent on the unproductive work i.e. about 30% of the total time. The variation was found in between sections and within sections among pluckers.

The observations on yield from 8 sections were taken between May and July, '76, keeping in view the spacing, jat, pruning treatment, round of plucking, plucking type and age of the bushes. Each time 5 pluckers were engaged for plucking for 30 minutes at the fixed time on different days.

The department arranged a study on 15 estates, 12 in Jorhat circle and 3 in Dooars for the period June to September '77.

(b) **Loading and Unloading Troughs :** From the management point of view the time in minutes taken to load or unload a trough would be the measure of efficiency. From the workers point of view the weight of leaves loaded or unloaded per minute would be a suitable measure. In the study latter point of view had been adopted as the troughs were not loaded uniformly or to their maximum capacity.

In case of loading the operation consists of three separate functions.

(a) Carrying baskets from trolleys to the trough.
(b) Spreading of green leaves heaps by hand to a uniform thickness.
(c) Cleaning the floor.

The productivity on the trough (downstairs) was 11.5 kg/Man Minute while on the trough (upstairs) it was 12.1 kg/mm.

Carrying : Carrying green leaf to the troughs (upstairs) was faster and the jugalis carried 20.9 kg/mm on average while the troughs (down stairs) the jugalis carried only 18.2 kg/mm.

Spreading : The average spreading down stair troughs was better than upstair troughs. On average 34.8 kg/mm was spread on downstair troughs while 33.7 kg/mm was found on the upstair troughs.

Cleaning : The average cleaning of troughs was faster in downstair troughs where 26.41 kg/mm was found while in upstair troughs the average was 15.75 kg/mm.

Unloading : The productivity of upstairs troughs at 16.98 kg/mm was higher than for downstairs at 16.43 kg/mm. The productivity of 2 men team at 17.97 kg/m was higher than that of 3 men team at 15.78 kg/m. It appeared that 2 men team adopting the method of work in which both men heap the leaves first and then take it to the conveyor was the best method of emptying the withered leaf. The estate where the study was conducted adopted the 2 men team for unloading the withered leaf from the start of next season.

Studies in Progress

5. **Economics of Rejuvenation** : The department undertook study during the period on Economics of Rejuvenation in the plains of North Eastern gardens. On the basis of prior information, 35 gardens were selected for study. Only 32 gardens from Assam Valley, Dooars and Terai supplied the rejuvenation figures regarding cost of rejuvenation and yield.

The cost of labour, material and overhead was taken for the period of $3\frac{1}{4}$ years. Labour charges included total wages (including fringe benefits). The cost of rejuvenation is being worked out.

The yield data available were mostly from 1973 to 1975. The department is collecting data for 1976 and 1977 also to work out the pay back period.

6. **Economics of Manuring** : This study is directed towards the evaluation of the benefits of manuring. The data was called in two parts, Part I, general data about the garden and Company, if any and Part II sectional data for the sections planted/replanted during the past 25 years.

The questionnaire was sent to 647 TRA member estates. The replies were received only from 97 estates for 915 sections.

Part I indicates that planting/replanting during the last 25 years was comparatively less in low yielding areas.

Processing of Part II has been taken up. The primary tabulation that is planned is a study of pattern of increase in yield from the 1st year of crop related to the type, quantity and frequency of manure applied.

Library and Publication

LIBRARY

General

Four new journals were added to the subscription list making the total of 143 journal heads in the Library. In addition to these, the Library receives 103 journals in exchange of Tocklai Publications and on free basis.

Reorganisation

Accessioning and classification of books are in progress. But due to departure of the Cataloguer, cataloguing of books are held up for sometime. Arrangement will be made to recruit a new Cataloguer to continue cataloguing works. A Bibliography on tea is being compiled. Weekly accession lists of books and journals are issued to Departments regularly. Paper cuttings on important topics relating to tea and other subjects have continued to be preserved. A classified subject index to 'Two & A Bud' is being prepared. Journals/Periodicals display boards in the reading room have been rearranged. Arrangement is being made to keep open the Library reading room after office hours from 2nd May, 1977.

Library Service

The Science students of undergraduate and Post-graduate classes of Assam Agricultural University, Scientists of Regional Research Laboratory, Jorhat; V.P. Trainees of T.R.A. Member Estates, Tea Board Trainees and a few research fellows in addition to Tocklai Scientists utilised the Library during the year.

Library Statistics

Total No. of books—4249
Books added during the year—178
Periodicals and Journals received—1600
New Journals added—6
Pamphlets and Bulletins 885
Photocopy 1
Reprints 4
Maps 50
Publications consulted in the Library 3700
Publications issued to Departments 1708
Books bound during the year 601.

PUBLICATION

The activities of the Publication Section continued to be increased this year.

The following publications were issued from Tocklai:

1. **Two and A Bud** : Vol. 23, Nos. 1 & 2.
2. **Tocklai News** : Nos. 3 & 4.

Advisory Bulletin :

3. No. 8 : Iron Particles in Tea, Edited by Dr. N. K. Jain.

Advisory Leaflet :

4. No. 10 : Tocklai Released Biclonal Stocks, by Dr. H. P. Bezbaruah.

Miscellaneous Reports :

5. Annual Scientific Report for 1975-76.
6. Engineering Research & Development Department Quarterly Reports for quarters ending 30th June, 30th September, 31st December, 1976 and 31st March 1977.
7. Proceedings of the Twenty Seventh Conference on November 13 through November 15, 1975, (August 1976).
8. Proceedings of the Engineering Seminar on April, 21 through April 23, 1975, (June 1976).

Appendix - A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
By
ADVISORY DEPARTMENT

South Bank, Assam

Project	Site	Index		Year of starting
NPK manuring of mature tea	Panitola	AS	108	1973
-do-	Thowra	AS	111	-do-
-do-	Rupai	AS	114	-do-
-do-	Diffloo	AS	120	-do-
Foliar application of zinc	Panitola	AS	109	-do-
-do-	Sepon	AS	112	-do-
-do-	Daimmkhia	AS	115	-do-
-do-	Bokakhat	AS	121	-do-
Shade in relation to tea nutrition	Thowra	AS	110	-do-
-do-	Bordubi	AS	113	-do-
-do-	Methoni	AS	119	-do-
Urea Trial	Duklingia	AS	125	-do-
Plucking Experiment	Nahortoli	AS	126	1974
-do-	Lohpohia	AS	133	-do-
Infilling Experiment	Halmari	AS	129	-do-
-do-	Kaliapani	AS	132	-do-
Rejuvenation Experiment	Tara	AS	128	-do-
-do-	Teloijan	AS	130	-do-
-do-	Khoomtai	AS	131	-do-
Cultivation Experiment	Deohall	AS	134	1975
NPK Experiment	Meleng	AS	142	1976
Young Tea Manuring	Deohall	AS	143	do

North Bank, Assam

NPK Manuring of mature tea	Naharani	AN	123	1973
-do-	Monabarrie	AN	116	,,
Shade in relation to tea nutrition	Dhulapadmng	AN	122	,,
-do-	Pertabghur	AN	118	,,
Response to foliar application of zinc	Tezpur & Gogra	AN	124	,,
-do-	Monabarrie	AN	117	,,
Rejuvenation	Kacharigaon	AN	135	1974
-do-	Tezpur & Gogra	AN	136	,,
-do-	Baghmari	AN	137	,,
Infilling	Kachari-gaon	AN	140	,,
-do-	Baghmari	AN	141	,,
Plucking	Dhullie	AN	139	,,
Nitrogen with and without mulch	Sessa	AN	138	1975

Cachar, Assam

Shade in relation to tea nutrition	Arcuttipore	C	42	1973
-do-	Pathemara	C	43	,,
Response to foliar application of zinc	Longai	C	41	,,
-do-	Silcoorie	C	40	,,
NPK manuring of mature tea	Silcoorie	C	38	,,
-do-	Longai	C	39	,,
Clonal response to N in different Agro-climatic regions	Coomber-gram	C	20	1962
Infilling	Longai	C	44	1974
Plucking	Hattikhira	C	45	,,
-do-	Silcoorie	C	46	1975
Rejuvenation	Isabheel	C	47	1974
-do-	Longai	C	48	1974

Project	Site	Index		Year of starting
Darjeeling				
NPK manuring of mature tea	Chongtong	Dj	34	1973
-do-	Nagrifarm	Dj	35	,,
Nitrogenous fertilizer	Lingia	Dj	29	1967
Clonal response to N in different agro-climatic regions	Nagrifarm	Dj	19	1961
P & K with and without weedic de	Chamong Nagri Sungma	Dj	31	1970
Pruning	Phoobsering	Dj	24	1965
-do-	Margarate's Hope	Dj	27	1966
Foliar application of zinc	Sungma	Dj	33	1973
-do-	Arya	Dj	32	,,
Infilling	Bannockburn	Dj	36	1974
-do-	Ging	Dj	37	,,
Rejuvenation	Bannock-burn	Dj	38	,,
-do-	Ging	Dj	39	,,
Dooars & Terai, West Bengal				
NPK manuring of mature tea	Nimtighora	D.	57	1973
-do-	Bagrakote	D.	55	,,
-do-	Sam Sing	D.	56	,,
-do-	Gungaram	RT.	7	,,
Nitrogenous Fertilizer	Baradighi	D.	33	1967
Clonal response to N in different Agro-climatic regions	Nya Sylee	D.	24	1962
Cultivation & Weed Control	Chuapara	D.	42	1970
Shade in relation to tea nutrition	Dalgaon	D.	51	1973
-do-	Gandrapara	D.	50	,,
Foliar application of zinc	Kartick	D.	52	,,
-do-	Bhogotpore	D.	54	,,
-do-	Baradighi	D.	53	,,
Infilling	Kartick	D.	41	1969
-do-	Jainti	D.	40	,,
-do-	Fague	D.	37	,,
-do-	Sahabad	TR	4	,,
-do-	Mohurgong & Gulma	TR	3	,,
Rejuvenation	Rydak	D.	46	1972
-do-	Dalgaon	D.	43	,,
-do-	Mateli	D.	44	,,
-do-	Kilcott	D.	45	,,
-do-	Kumlai	D.	47	,,
-do-	Gungaram	TR.	5	,,
Plucking	Birpara	D.	58	1974
-do-	Dalsengpara	D.	59	,,
-do-	Hansqua	D.	60	,,
Clone Vs Nitrogen Trial	Nagrakata	D.	48	1973
Potash Soil Sampling Trial	Batabari	D.	49	,,
Long Term Trial	Nagrakata	D.	61	1974
New Long Term Trial	Nagrakata	D.	62	1975
Irrigation	Dam Dim	D.	63	1976
-do-	Jainti	D.	64	1977

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATE
By
THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

List of estates under clonal selection Scheme

Sl. No.	Name of Estate	Year of starting
South Bank, Assam		
1.	Heeleakah	1972
2.	Duk!ingia	1973
3	Basabari	1974
4	Borbam	1975
5.	Dahingiapara	1975
6.	Sotai	1975
7.	Bukhial	1975
8.	Dilli	1976
9.	Cherideopurbat	1976
10.	Tingalibam	1976
11.	Longboi	1976
12.	Dinjan	1976
13.	Gabru Purbat	1976
North Bank, Assam		
1.	Durrung	1975
2.	Bhootcachang	1975
3.	Dimakusi	1975
4.	Borengajuli	1975
5.	Attarcekhat	1975
6.	Birjhora	1976
7.	Nagrijuli	1976
8.	Dhunseri	1976
9.	Tarajuli	1976
10.	Gingia	1976
11.	Halem	1976
12.	Chapar	1976
13.	Choibari	1976
14.	Kokrajhar	1976
15.	Mornoi	1976

Sl. No.	Name of estate	Year of starting
Cachar		
1.	Chandighat	1976
2.	Burtoll	1976
3.	Poloi	1976
4.	Narsingpore	1976
5.	Longai	1976
Dooars and Terai, West Bengal		
1.	Kailaspur	1976
2.	Gopalpur	1976
3.	Chuapara	1976
4.	Central Dooars	1976
5.	Kartick	1976
6.	Rydak	1976
7.	Leesh River	1976
8.	Baintgooric	1976
9.	Birpara	1976
10.	Gargandra	1976
11.	Subhasini	1976
12.	Dalsingpara	1976
13.	Gaya ganga	1976
14.	Tirrihana	1976
15.	Mohorgong & Gulma	1976
16.	Bijoynagar	1976
17.	Panighatta	1976
Darjeeling		
1.	Happy Valley	1975
2.	Soom	1975
3.	Tukvar	1975
4.	Lingia	1975
5.	Sungma	1975
6.	Runglee	1975
7.	Balasun	1975
8.	Singbuli	1975

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiments	Location of estate	Site	Index No.	Year of starting
1.	Incidence of Red spider in relation to longer pruning cycle	South Bank, Assam	Thowra T.E.	6	1976/77
2.	Incidence of Shot hole borer	,,	Sycotta T.E.	,,	1976/77
3.	Incidence of Mites in relation to micronutrients	Dooars	Meanglass T.E.	,,	1976/77
4.	Incidence of thrips in different pruning cycle	,,	Nagaisuri T.E.	,,	1976/77
5.	Red spider trial (prophylactic) palliative	South Bank, Assam	Dhoolie T.E.	,,	March,1977
			Dooria T.E.	,,	,, ,,
6.	Jassid control trial	,,	Anandabari	,,	June,1976
7.	Thrips control trial	,,	,,	,,	June, 1976
8.	Thrips control trial	Darjeeling	Balasun	,,	May, 1976
9.	Scale insect Control	,,	Arya T.E.	,,	Sept, 1976
10.	Looper control trial	South Bank	Diffloo T.E.	,,	May, 1976
			Thorajan T.E.	,,	May, 1976.
11.	Termite control trial	Cachar	Arcuttipore T.E.	6	March, 1976

MYCOLOGY DEPARTMENT

Sl. No.	Experiment	Location	Site	Index No.	Year of starting
1.	To study the protective action of lower concentration of a copper oxychloride against red rust when applied with a hand sprayer	South Bank, Assam	Bokahola	MRO18	1975
2.	Same as above, but with a power sprayer	,,	,,	MRO 19	1975
3.	Screening of different formulations against Red rust.	,,	Dahingcapar	MRO 21	1976
4.	Evaluating a new fungicide against Thorny stem blight	Darjeeling	Happy Valley	MCO 06	1975
5.	Screening of fungicides against Black rot	South Bank, Assam	Gobindapur	MBO 14	1976
6.	-do-	,,	Kakajan	MBO 15	1976
7.	Study the effects of application of different concentration of a-copper oxychloride fungicide in controlling Black rot with hand sprayer	,,	,,	MBO 16	1976
8.	Screening of fungicide against Blister blight with power sprayer	Darjeeling	Marybong	MF 006	1976
9.	Screening of fungicide against Blister blight using hand sprayer	,,	Bloomfield	MF 007	1976
10.	Effect of different treatments on the control of Blister blight-blight and yield return	Darjeeling	Arya	MF 005	1976
11.	Chemical control of primary root disease	South Bank, Assam	Nahorkutia	MP 002	1974
12.	-do-	,,	Borhat	MP003	1975
13.	-do-	North Bank, Assam	Tarajuli	MP004	1975
14.	-do-	,,	Thakurbari	MP006	1975
15.	-do-	Darjeeling	Balasun	MP005	1974
16.	-do-	South Bank, Assam	Dilli	MP007	1976

STATISTICS DEPARTMENT

Sl. No	Department	Project	Site	Index No.	Year of starting
1.	Statistics	Uniformity trial	Nagri Farm (Darjeeling, West Bengal)		1964

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl. No	Experiment	Location of site	Year of starting
1.	Trial of Continuous Tea Roller	South Bank, Borbam T. E.	1975
2.	Trial of Withered Leaf Preconditioner	-do-	1976

Appendix-C

PUBLISHED PAPERS & PAPERS IN THE PRESS

Bezbaruah, H.P. 1976. Aneuploidy in Tea. *The Nucleus* 19 (3) : 167-169.

(Abs. A number of aneuploids and polyploids in tea (Camellia sinensis L.) have been identified from the progeny of a natural triploid (2n = 45). The majority were near tetraploid level. Considerable morphological variation exists amongst the aneuploids, which should be useful : (1) in identifying chromosomes associated with specific characters; and (2) in transmitting desirable genetic traits in tea breeding. A few of the plants appears to be aneusomatic in character.)

Biswas, Ajit Kumar & Biswas, Asim Kanti. 1976. Statistical Techniques Development for Experimentation with Tea in North India. *Proc. of the 22nd Scientific Conf.* Bull. No. 33 *UPASI,:* 156-172.

(Abs. The study on the search for an alternative ancillary variable for covariance analysis to replace pretreatment whole season's crop showed that the pretreatment crop from September to end season was efficient for adjusting the post-treatment crop of individual year as well as cumulative total crop of all subsequent years of experimentation in the Assam Valley and Dooars. In Cachar and Darjeeling, pretreatment July-August crop was found to be as efficient as the whole season's crop. Results suggest that taking of the pretreatment crop from September to end season in the Assam Valley and Dooars, and July-August crop in Darjeeling and Cachar will be sufficient. Application of these results will, minimise the cost and increase the efficiency of the field experiments, if an experimenter decides to lay out an experiment at the middle of the season, he need not waste one more complete year to take the pretreatment whole season's crop to increase the efficiency of the experiment. Number of observations necessary for field experimentation with tea in North East India, revealed that crop of each period of the whole season was as efficient as the whole season's crop for comparison of the treatments within an experiment both for individual year as well as combined over years of experimentation. This suggests that crop from any one of the two periods of the whole season will enable the experimenter to make the treatment comparisons without any loss of experimental accuracy. This will enable the experimenter to do double the number of experiments with the same number of supervisors, which will minimise the cost.)

Manivel, L. & Weaver, R. J. 1976. Effect of growth regulators on stomatal closure in grapes. *Madras Agri J.* 63(4) : 244-245.

(Abs. Different growth regulators were tested for their ability to bring forth stomatal closure and opening in intact leaves of vinifera grape vine. Abscisic acid (ABA) at 100 ppm resulted in a high degree of stomatal closure with maximum closure occuring 30-45 min. after application. The ABA induced stomatal closure was almost reversed within 15 min. by benzyl adenine (BA) at 1000 ppm. Stomata of half expanded leaves responded better than those of recently mature or older leaves. Interaction among the endogenous growth hormones may play a role in regulating the stomatal opening or closure in plants.)

Rao, V.S. & Duke, W.B. 1976. Effect of alachlor, propachlor and prynachlor on GA_3—induced production of protease and α-amylase. *Weed Sc.* 24:616-618.

(Abs. Alachlor [2-chloro 2', 6'-diethyl-N methoxymethyl) acetanilide], propachlor [2-chloro—N-isopropylacetanilide) and prynachlor [2-chloro-N-(1-methyl 2-propynyl) acetanilide), inhibited gibberellic acid (GA_3) induced production of protease and α-amylase in deembryonated barley (*Hordeum vulgare* L, 'Schuyler') seed. Production of protease was more sensitive to these herbicides than α-amylase. The degree of inhibition of protease and α-amylase production caused by alachlor was equivalent to that caused by cycloheximide, puromycin and acitomycin-D, known protein and nucleic acid synthesis inhibitors. Higher GA_3 concentrations reversed the inhibition of protease and α-amylase synthesis caused by alachlor but did not reduce the effect of alachlor on barley seed germination and growth. It is concluded that the inhibition of protease and α-amylase production by alachlor is perhaps only one of several effects on early seed germination and seedling development.)

Rao, V.S., Braun, J. W. & Khan, A. A. 1976. Release of lettuce seed thermodormancy by plant growth regulators applied in organic solvent. *Hortscience* 11:29-70.

(Abs. The emergence of lettuce (*Lactuca sativa* L. cvs. Grand Rapids and Mesa 659) seeds was en-

hanced by the pre-sowing permeation via acetone of growth regulators into the dry seeds. Emergence of photosensitive 'Grand Rapids' seeds from soil medium at moderate temperatures (20–18 C) was enhanced by permeation with gibberellic acid (GA_3) alone. At supraoptimal soil temperatures, emergence of both cultivars was enhanced most effectively by a combination of GA_3, kinetin and (2-chloroethyl phosphonic acid) ethephon.)

Rao, V.S. Braun, J.W. & Khan, A.A. 1976. Promotive effects of organic solvents and kinetin on dark germination of lettuce seeds. *Plant Physiol* 57:446-449.

(Abs. Significant promotion in dark germination was observed when Grand Rapids lettuce (*Lactuce sativa* L.) seeds were soaked in acetone or dichloromethane, vacuumdried, and imbibed at 25°C. Permeation of kinetin via these organic solvents further enhanced the dark germination. Those seeds that were affected by acetone and acetone-kinetin treatments and germinated in the dark escaped red-far red photocontrol of germination. Although abscisic acid was not detected in the organic solvent leachates, they did contain other inhibitory substances affecting lettuce seedling growth. In the light, acetone and acetone-kinetin treatments also enhanced the rate of germination and the increased germination by acetone-kinetin treatment was correlated with increased polyribosome formation. The possible mechanisms involved in promotion of lettuce seed germination by organic solvents and kinetin are discussed.)

Rao, V.S., Rahman, F., Singh, H.S., Dutta, A.K. & Saikia, M.C. 1977. Advances in weed research in tea of Northeast India. *Proc. of Weed Sci. Conf./Workshop, Indian Soc. Weed Sci.* Part I (in press)

(Abs. Approximately 55% of the area under tea (Camellia sp.) in Northeast India is under herbicides and this accounts for about 70% of the herbicides marketed in India. This achievement is mostly due to the pioneering research done by Tocklai on chemical weed control in the past 25 years. During this time, a number of new chemicals have been tested, and effective herbicides and herbicide combinations selected and recommended for nursery, young tea, and mature tea areas. Efficacy of herbicides, persistence of toxicity, phytotoxicity to tea plant, and effect of herbicides on quality of cup tea were the main criteria used in developing these recommendations. This was made possible by a well organized herbicide testing and certification programme.)

Rao, V.S., Rahman, F., Singh, H.S., Dutta, A.K., Saikia, M.C., Sharma, S.N., & Phukan B.C. 1977. Effective weed control in tea by glyphosate. *Proc. Weed Sci. Conf./Workshop. Indian Soc. Weed Sci.* Part II (in press)

(Abs. Glyphosate effectively controlled perennial grassy weeds such as *Imperata-cylindrica* (L.) Beauv., *Paspalum conjugatum* Berg., *Paspalum scrobiculatum* L., *Arundinella bengalensis* (Spreng) Druce., and *Setaria palmifolia* (Koen.) Stapf. at rates ranging from 0.4 to 2.4 kg/ha. Glyphosate was also found effective on broadleaf weeds like *Borreria hispida* (L.) K. Schum., *Polygonum chinense* L., and *Commelina benghalensis* L.

Addition of Triton AE, a wetting and sticking agent, has no effect on glyphosate activity. It, however, reduced rainwash of glyphosate off weed foliage occurring 1 or 2 hr after herbicide application. Triton AE had no effect if the rainfall was delayed by 4 hr or more after glyphosate application. Addition of ammonium sulphate upto 6 kg/ha enhanced the rate of glyphosate activity. Application of 2,4-D as a tank mix with glyphosate enhanced the rate of activity of the latter. This synergistic effect helped reduce the rate of application of glyphosate substantially for effective weed control.)

Rao, V.S. & Khan, A.A. 1977. Antidotal action of R-25788 on EPTC and alachlor injury to corn and barley. *Proc. Weed Sci. Conf./Workshop, Indian Soc. Weed Sci.* Part II (in press)

(Abs. Application of R-25788 (0.84 kg/ha) as tank mix with alachlor (1.12 kg/ha) had significantly reduced herbicide injury on barley seedling growth. Similar protective action by the antidote was not evident on an annual grass weed. Molecular level investigations indicated that antidote and alachlor compete for the same active site(s) of action resulting in accumulation of herbicide in the plant tissue at a level lower than necessary to cause absolute toxicity)

Appendix - D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1976

Table : 1 Tocklai (Mid Assam)

Latitude : 26°47' N Longitude : 94°12' E Altitude : 96.5 meters a.m.s.l.

Months 1976	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature C (under grass)			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	23.1 (22.3)	9.9 (9.4)	16.5 (15.8)	24.8	7.2	0.0 (21.7)	0 (5)	7.2 (5.9)	17.8 (18.6)	17.7 (18.2)	18.6 (19.0)	36.3	64.8
February	23.5 (24.1)	13.9 (11.9)	18.7 (18.0)	28.7	10.3	44.3 (31.9)	12 (7)	6.1 (6.2)	20.6 (20.4)	20.0 (19.8)	20.4 (20.2)	51.6	82.5
March	27.5 (27.5)	16.5 (15.5)	22.0 (21.5)	31.5	10.5	60.3 (79.5)	11 (11)	7.6 (6.7)	24.1 (24.0)	23.4 (23.1)	23.2 (23.1)	94.8	131.3
April	29.5 (28.7)	19.1 (19.0)	24.3 (23.8)	33.6	16.1	157.7 (192.7)	14 (16)	7.0 (5.9)	26.8 (26.8)	26.2 (25.8)	26.0 (25.6)	112.7	149.6
May	29.9 (29.9)	22.3 (21.8)	26.1 (25.8)	35.0	18.5	192.6 (280.0)	16 (20)	6.6 (5.0)	29.1 (28.7)	28.2 (27.8)	28.0 (27.6)	106.9	168.0
June	30.1 (31.5)	24.0 (24.1)	27.0 (27.8)	34.0	20.3	327.7 (330.6)	26 (23)	4.0 (4.5)	29.6 (30.7)	29.2 (29.7)	29.3 (29.6)	85.3	141.3
July	32.0 (32.2)	24.9 (24.6)	28.4 (28.4)	34.7	22.7	356.7 (380.9)	27 (25)	6.3 (4.7)	31.6 (31.4)	30.8 (30.6)	30.8 (30.5)	109.8	174.8
August	31.5 (32.0)	24.7 (24.6)	28.1 (28.3)	35.2	23.2	417.3 (343.3)	25 (23)	4.9 (5.1)	30.8 (31.4)	30.4 (30.6)	30.6 (30.6)	92.3	151.4
September	31.5 (31.2)	24.3 (23.9)	27.9 (27.6)	34.3	22.4	314.2 (254.1)	21 (19)	6.7 (5.0)	31.0 (30.8)	30.5 (30.2)	30.6 (30.2)	86.6	150.4
October	29.2 (29.3)	20.7 (21.0)	25.0 (25.2)	31.6	17.6	71.1 (118.4)	9 (12)	6.7 (5.6)	28.0 (28.4)	27.7 (28.0)	28.3 (28.4)	71.8	121.6
November	26.3 (26.3)	17.8 (15.2)	22.0 (20.8)	30.3	13.1	39.1 (27.4)	12 (4)	4.7 (6.1)	24.0 (24.0)	24.1 (23.7)	25.0 (24.5)	39.3	74.8
December	23.2 (23.1)	11.7 (10.6)	17.1 (17.0)	25.7	7.6	15.8 (11.0)	3 (3)	6.3 (6.3)	19.2 (19.7)	19.0 (19.5)	20.6 (20.6)	29.9	60.2

PERCENT RELATIVE HUMIDITY

Table : 1(a) Tocklai

Hours of observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 13	93 (96)	94 (94)	90 (92)	90 (91)	90 (92)	93 (92)	93 (93)	94 (94)	94 (95)	95 (96)	95 (96)	95 (96)
13 13	52 (58)	59 (51)	51 (53)	56 (63)	67 (71)	78 (75)	71 (75)	75 (75)	72 (74)	66 (72)	68 (64)	61 (60)

Notes : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are mean of morning and afternoon records
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1976

Table : 2 Sicloorie (Cacher)

Latitude : 24°50' N Longitude : 92°48' E Altitude : 39.6 meters a.m.s.l.

Months 1976	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	Depth 15 cm	Depth 30 cm	Open Pan in mm	Penman in mm
January	26.1 (25.9)	10.9 (10.9)	18.5 (18.4)	27.4	8.2	0.0 (18.6)	0 (2)	7.9 (8.0)	21.2 (21.3)	?	?	58.3	79.4
February	27.9 (27.6)	14.4 (12.8)	21.2 (20.2)	31.8	10.4	26.8 (51.8)	4 (4)	8.1 (8.2)	24.0 (23.2)	?	?	85.3	106.5
March	29.8 (30.8)	18.0 (16.4)	23.9 (23.6)	33.8	10.3	251.2 (101.4)	13 (7)	8.2 (8.1)	26.9 (26.9)	?	?	109.3	148.6
April	31.3 (31.9)	20.4 (20.4)	25.8 (26.2)	34.7	17.0	471.4 (253.0)	13 (14)	7.3 (7.6)	28.8 (29.3)	?	?	104.0	171.2
May	31.7 (31.8)	23.1 (22.7)	27.4 (27.2)	35.6	19.0	263.7 (382.4)	22 (19)	7.5 (6.5)	30.0 (30.5)	?	?	90.1	182.6
June	29.8 (31.6)	23.8 (24.4)	26.8 (28.0)	34.1	21.0	1024.2 (590.8)	26 (24)	3.8 (4.2)	28.9 (30.7)	?	?	70.0	135.6
July	31.7 (32.0)	24.7 (24.9)	28.2 (28.4)	35.3	22.6	569.2 (525.2)	27 (27)	4.9 (4.3)	30.6 (31.3)	?	?	62.5	156.3
August	31.3 (32.2)	24.3 (24.9)	27.8 (28.6)	34.9	22.7	534.8 (428.5)	27 (25)	4.9 (4.9)	30.7 (31.5)	?	?	72.3	151.0
September	32.1 (32.3)	24.1 (24.4)	28.1 (28.4)	35.6	20.3	438.0 (336.1)	18 (18)	7.7 (5.6)	31.2 (31.2)	?	?	90.0	161.8
October	30.7 (31.4)	21.3 (22.5)	26.0 (27.0)	32.1	17.4	67.6 (211.0)	8 (11)	7.4 (6.6)	29.4 (29.6)	?	?	79.7	135.3
November	29.4 (29.2)	18.6 (17.3)	24.0 (23.2)	33.7	14.7	51.4 (35.6)	6 (3)	8.0 (7.8)	26.8 (26.0)	?	?	68.9	105.2
December	25.7 (26.8)	11.9 (12.4)	18.8 (19.6)	27.3	9.4	0.0 (10.1)	0 (1)	8.7 (8.0)	21.6 (22.5)	?	?	51.3	78.6

PERCENT RELATIVE HUMIDITY

Table : 2(a) Silcoorie

Hours of observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 19	98 (98)	98 (97)	94 (94)	92 (91)	93 (91)	96 (95)	95 (96)	96 (96)	94 (95)	96 (96)	96 (97)	98 (98)
13 19	48 (47)	48 (43)	57 (43)	58 (57)	67 (67)	82 (76)	75 (76)	77 (74)	68 (71)	64 (68)	61 (57)	53 (49)

Notes : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are mean of morning and afternoon records
(iii) Penman in mm means Penman estimation of evaporation from an open water surface
(iv) ? indicates data not available,

SUMMARY OF METEOROLOGICAL OBSERVATION DURING 1976

Table : 3 Nagrakata (Dooars)

Latitude : 26°54' N Longitude : 88°55' E Altitude : 228.6 meters a. m. s. l.

Months 1976	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	23.9 (23.6)	10.3 (10.4)	17.1 (17.0)	25.7	7.4	6.6 (12.5)	1 (2)	7.4 (7.6)	18.6 (18.2)	19.0 (18.4)	20.1 (19.6)	69.6	76.4
February	23.8 (25.5)	13.1 (12.8)	18.4 (19.2)	27.4	7.5	107.6 (20.0)	6 (3)	6.3 (7.4)	19.4 (20.2)	19.7 (20.0)	20.2 (20.6)	83.0	88.3
March	? (29.4)	16.1 (16.4)	? (22.9)	?	12.5	7.3 (39.6)	2 (5)	8.4 (7.6)	24.5 (24.2)	24.2 (23.8)	24.1 (23.8)	157.3	150.3
April	? (31.1)	19.6 (20.1)	? (25.6)	?	15.7	108.4 (139.9)	6 (11)	6.5 (7.1)	28.1 (27.0)	27.5 (26.4)	27.8 (26.6)	187.2	159.9
May	29.5 (30.8)	21.4 (21.7)	25.4 (26.2)	31.1	18.6	466.0 (346.0)	22 (20)	6.2 (6.5)	27.6 (28.3)	27.6 (27.7)	27.6 (28.0)	138.0	165.2
June	29.6 (30.4)	22.6 (23.4)	26.1 (26.9)	31.0	20.0	1161.2 (878.2)	26 (26)	3.7 (3.9)	27.6 (28.6)	27.7 (28.0)	28.0 (28.4)	109.1	131.3
July	30.7 (30.3)	23.3 (23.8)	27.0 (27.0)	33.2	22.4	767.5 (1088.0)	28 (27)	4.5 (3.3)	29.3 (28.8)	28.2 (28.3)	29.2 (28.6)	114.4	150.3
August	29.9 (30.7)	22.1 (23.8)	26.0 (27.2)	33.0	21.1	903.0 (752.3)	28 (27)	3.8 (4.1)	28.3 (29.0)	28.0 (28.7)	28.8 (28.8)	107.0	128.9
September	31.1 (30.5)	21 1 (22.9)	26.1 (26.7)	32.7	19.3	553.6 (552.8)	21 (22)	6.5 (5.0)	28.9 (28.7)	28.4 (28.6)	29.2 (28.6)	110.5	140.0
October	29.8 (29.8)	17.6 (19.7)	23.7 (24.8)	31.6	14.5	133.2 (225.1)	15 (10)	8.7 (7.7)	26.8 (26.8)	27.0 (27.2)	27.7 (27.4)	101.8	132.3
November	27.2 (27.4)	15.7 (14.7)	21.4 (21.0)	31.8	12.0	140.8 (11.6)	9 (3)	6.7 (8.7)	24.0 (22.6)	24.2 (23.0)	25.2 (24.1)	70.5	86.0
December	24.0 (24.8)	12.2 (11.5)	18.1 (18.2)	25.1	10.1	1.0 (3.5)	2 (1)	7.9 (8.4)	19.8 (19.4)	20.4 (19.8)	21.4 (21.0)	57.9	69.8

PERCENT RELATIVE HUMIDITY

Table 3(a). Nagrakata (Dooars)

Hours of observations in IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0634	84 (85)	80 (82)	70 (74)	69 (76)	89 (87)	95 (95)	95 (96)	96 (95)	94 (95)	91 (89)	89 (85)	90 (86)
1334	50 (51)	57 (48)	34 54	44 (53)	67 (69)	83 (82)	77 (83)	82 (81)	74 (78)	66 (67)	62 (56)	56 (53)

Notes : (i) Data in brackets shows previous averages.
(ii) Soil Temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm menans Penman's estimation of evaporation from an open water surface.
(iv) ? indicates data not available.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1976

Table : 4 Nagri Farm (Darjeeling)

Latitude : 26 55′ N Longitude : 88°12′ E Altitude : 1158.2 meters a. m. s. l.

Months 1976	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open Pan in mm	Penman in mm
January	13.9 (15.2)	7.9 (7.8)	10.9 (11.5)	16.1	6.5	34.9 (18.7)	5 (3)	5·0 (6.1)	12.0 (13.2)	10.6 (12.2)	13.4 (14.0)	40.9	50.8
February	16.6 (16.7)	9.4 (9.5)	13.0 (13.1)	19.9	6.7	79.8 (17.1)	6 (3)	5.4 (5.9)	14.0 (14.8)	12.0 (13.4)	14.0 (14.5)	52.8	72.1
March	22.3 (21.4)	13.6 (13.1)	18.0 (17.2)	25.9	7.0	3.0 (49.6)	2 (5)	8.5 (6.8)	20.8 (19.1)	17.2 (17.2)	18.4 (17.7)	133.6	140.6
April	? (23.7)	16.3 (15.9)	? (19.8)	?	13.0	136.4 (100.7)	8 (11)	6.8 (5.7)	22.6 (21.9)	21.8 (20.0)	22.3 (20.4)	152.0	145.7
May	23.1 (23.9)	16.6 (17.1)	19.8 (20.5)	25.9	14.2	158.9 (196.1)	23 (19)	4.6 (5.2)	23.2 (23.5)	21.7 (21.8)	22.0 (22.0)	77.0	128.4
June	23.1 (24.1)	18.2 (18.8)	20.6 (21.4)	25.5	16.2	450.9 (440.2)	23 (25)	2.0 (3.0)	23.6 (24.5)	21.7 (23.1)	22.7 (23.2)	53.7	103.3
July	24.0 (24.3)	19.0 (19.3)	21.5 (21.8)	27.2	18.0	333.2 (676.4)	22 (27)	3.1 (2.4)	24.8 (24.8)	28.0 (23.3)	23.9 (23.8)	60.3	118.1
August	23.2 (24.8)	18.5 (19.1)	20.8 (22.0)	25.5	17.4	707.6 (158.9)	28 (25)	2.8 (3.3)	23.6 (25.4)	22.3 (23.8)	23.4 (24.2)	67.2	106.6
September	24.2 (24.4)	17.9 (18.2)	21.0 (21.3)	25.1	15.0	261.7 (328.4)	17 (20)	4.9 (3.9)	24.4 (24.3)	22.6 (23.0)	24.0 (23.6)	68.2	112.2
October	22.3 (23.4)	15.0 (15.8)	18.6 (18.6)	24.8	11.2	50.0 (140.2)	5 (8)	7.0 (6.6)	22.1 (22.2)	20.6 (20.9)	23.8 (21.9)	71.0	104.8
November	19.7 (20.6)	13.0 (11.9)	16.1 (16.2)	25.7	10.2	7.9 (11.6)	1 (2)	5.0 (7.4)	19.2 (18.2)	17.9 (17.0)	19.7 (18.8)	45.0	67.3
December	16.3 (17.6)	9.0 (9.2)	12.6 (13.4)	18.8	7.0	0.0 (3.4)	0 (1)	5.5 (6.8)	14.6 (14.6)	13.6 (13.6)	16.0 (15.6)	38.2	52.5

PERCENT RELATIVE HUMIDITY

Table 4(a). Nagri Farm

Hours of observations IST	Jan	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637	75 (71)	76 (70)	54 (63)	63 (68)	84 (81)	92 (92)	91 (94)	93 (93)	90 (89)	74 (78)	78 (67)	74 (69)
1337	73 (72)	72 (65)	45 (58)	57 (66)	82 (82)	89 (89)	87 (89)	89 (86)	84 (86)	78 (79)	79 (70)	74 (70)

Notes : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penmen in mm means Penman estimation of evaporation from an open water surface,
(iv) ? indicates data not available,

SUMMARY OF METEOROLOGICAL OBSERVATION DURING 1976

Table : 5 Thakurbari (North Bank)

Latitude : 26°48′35″ N Longitude : 92°42′ 35 E Altitude : 92.45 meters a. m. s. l.

Months 1976	Daily temperature °C					Rainfall.		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth			Open Pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	24.9	9.1	17.0	26.3	6.4	14.3	2	8.3	?	?	?	47.77	54.1
	(23.8)	(8.6)	(16.2)			(26.3)	(4)	(7.5)					
February	26.6	13.4	20.0	28.9	8.4	35.4	5	6.4	?	?	?	66.2	91.6
	(26.0)	(11.5)	(18.8)			(6.8)	(3)	(7.1)					
March	29.6	15.8	22.7	34.2	9.7	104.6	3	8.8	?	?	?	114.7	137.1
	(30.4)	(15.0)	(22.7)			(25.0)	(3)	(7.0)					
April	32.0	18.5	25.2	34.7	14.6	108.8	5	8.3	?	?	?	123.0	170.8
	(30.5)	(19.9)	(25.2)			(192.0)	(17)	(6.2)					
May	31.4	21.2	26.3	36.4	18.4	192.6	14	7.2	?	?	?	123.8	174.9
	(31.0)	(21.9)	(26.4)			(222.2)	(16)	(6.0)					
June	30.7	23.2	27.0	34.9	20.9	555.8	25	3.7	?	?	?	92.9	134.9
	(31.6)	(24.3)	(28.0)			(425.6)	(22)	(4.4)					
July	32.2	24.1	28.2	35.4	21.9	469.4	21	5.8	?	?	?	99.2	166.2
	(32.0)	(24.8)	(28.4)			(540.6)	(28)	(4.4)					
August	31.8	24.1	28.0	35.7	22.2	284.1	24	4.7	?	?	?	94.6	148.1
	(32.6)	(24.8)	(28.7)			(316.8)	(18)	(5.5)					
September	32.9	23.2	28.0	35.7	22.0	203.3	18	6.8	?	?	?	98.0	149.3
	(31.3)	(23.4)	(27.4)			(348.2)	(20)	(5.3)					
October	30.1	19.0	24.6	32.7	15.0	118.4	9	7.2	?	?	?	81.5	122.6
	(30.8)	(21.6)	(26.2)			(217.4)	(12)	(6.4)					
November	28.3	16.2	22.2	31.8	?	5.8	5	6.5	?	?	?	55.2	84.9
	(28.3)	(14.8)	(21.6)			(10.6)	(1)	(8.2)					
December	24.9	10.5	17.7	29.9	5.5	5.5	3	7.7	?	?	?	43.4	65.2
	(24.5)	(9.2)	(16.8)			(16.4)	(4)	(8.7)					

PERCENT RELATIVE HUMIDITY

Table 5(a). Thakurbari (North Bank)

Hours of Observations IST.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	94	93	86	84	90	93	94	95	94	93	94	94
	(93)	(91)	(84)	(87)	(90)	(93)	(94)	(93)	(93)	(93)	(93)	(94)
1319	50	58	66	51	67	82	76	78	72	68	68	57
	(54)	(50)	(47)	(64)	(70)	(75)	(77)	(75)	(76)	(72)	(60)	(56)

i) Data in brackets shows previous averages.
ii) Soil temperature at different depths are the mean of morning and afternoon readings.
iii) Penman in mm means Penman's estimation of evaporation from an open water surface.
iv) ? indicates data not available.